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Pasadena, California

Atmospheric Infrared Sounder

EVALUATING CMIP5 MODELS USING AIRS OBSERVATIONS

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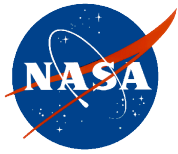
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AIRS Observations for CMIP5 Simulations

- The next IPCC Assessment Report, AR5, will rely on peer reviewed analysis of model outputs from the Coupled Model Intercomparison Project Phase 5 (CMIP5) experiments, which are now being delivered to the Earth System Grid (ESG). NASA has identified several sets of satellite observations that correspond to some of these model outputs, which can be used to evaluate the experiments.
- Monthly averaged air temperature ([ta](#), Kelvin) and specific humidity ([hus](#), kg/kg) from AIRS/AMSU combined retrievals were identified as two of such data sets, and are provided with the following characteristics:
 - For each month from Sept 2002 to May 2011 (time)
 - On a global spatial grid (lon, lat) at 1 degree by 1 degree resolution
 - On the CMIP5 mandatory vertical pressure levels (plev) from 1000 hPa to 300 hPa
- We provide one technical note for each dataset describing strengths/weaknesses, uncertainties, and critical caveats for comparing AIRS data to CMIP5 model outputs.
- The AIRS data have been staged at the JPL/ESG gateway for public access since early 2011, as the first test data sets for NASA observations.



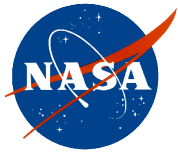
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Objectives

- To document the characteristics of the AIRS/CMIP5 data set in terms of climatology and seasonal cycle.
- To evaluate CMIP5 models using the AIRS/CMIP5 data set.

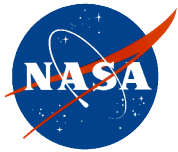


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AIRS Data Characteristics



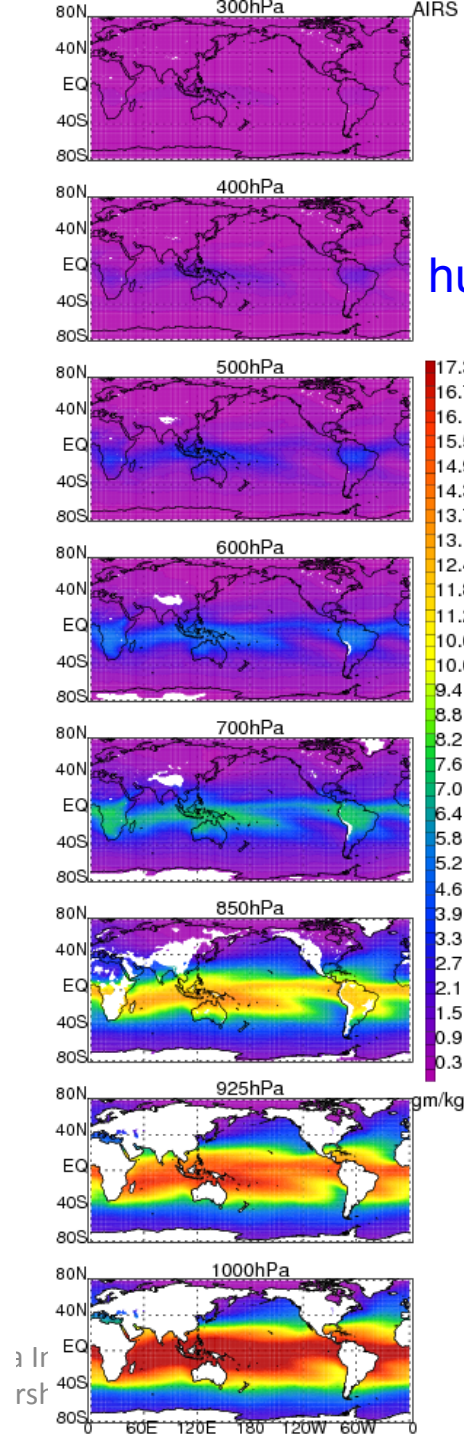
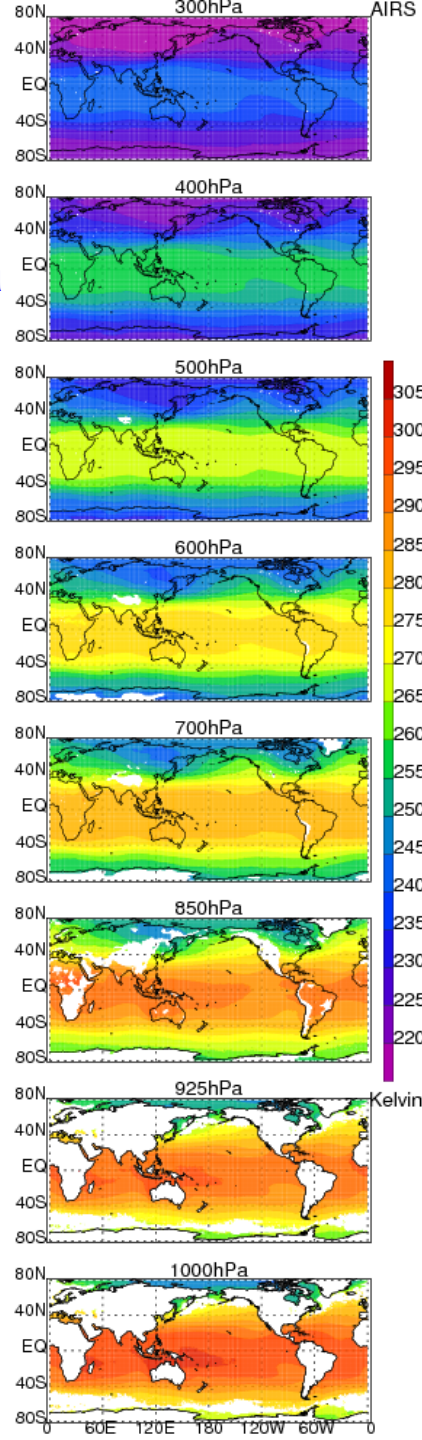
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ta

- Ta decreases with both latitude and altitude.
- Strong zonal ta gradient exists in boundary layer (≥ 850 hPa) but weak in the free troposphere (≤ 700 hPa).



Climatology

hus

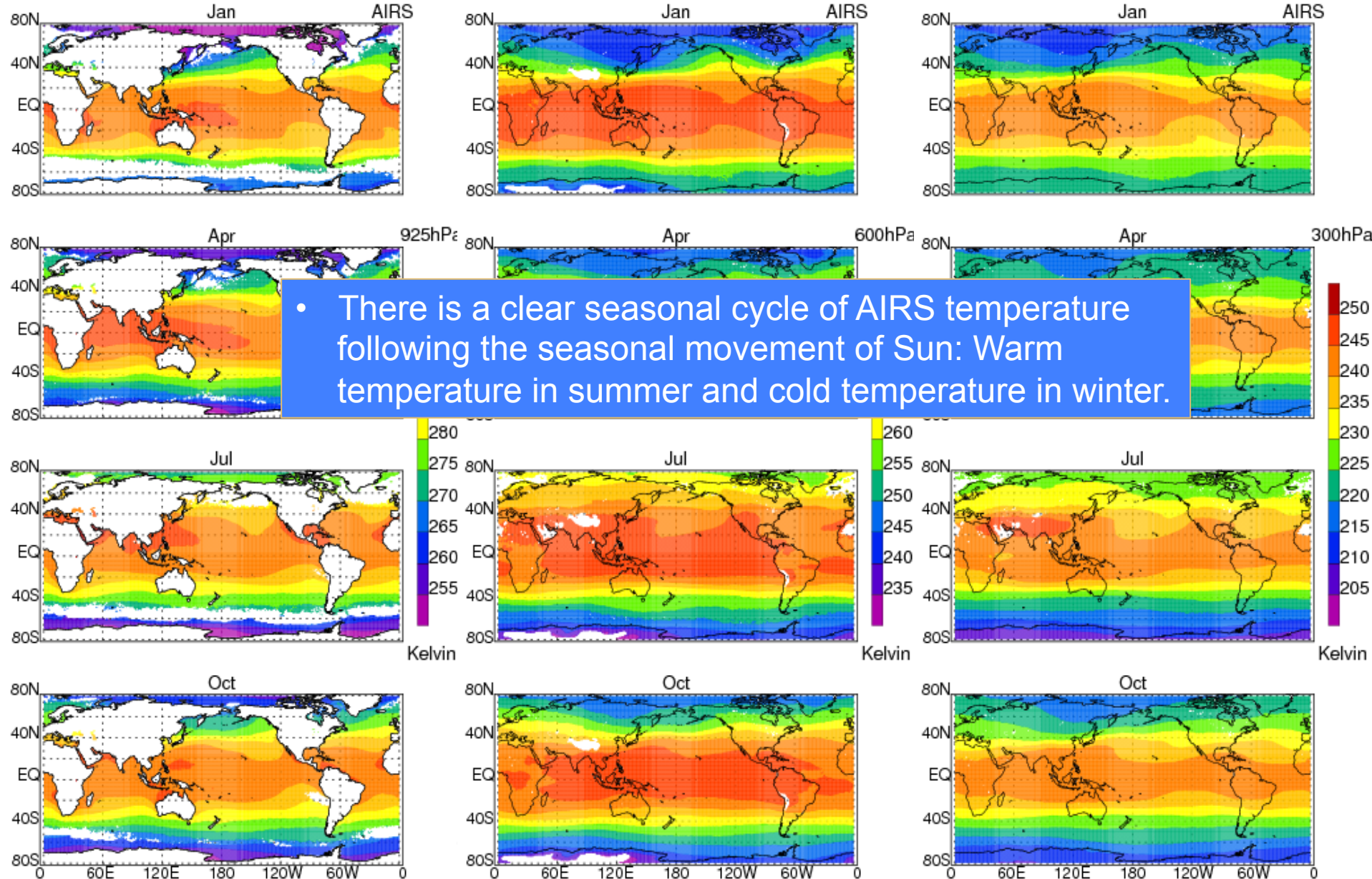
- Hus decreases with both latitude and altitude.
- Strong zonal hus gradient exists in all levels.
- Clear separation of ITCZ and SPCZ.



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AIRS Temperature Seasonal Cycle

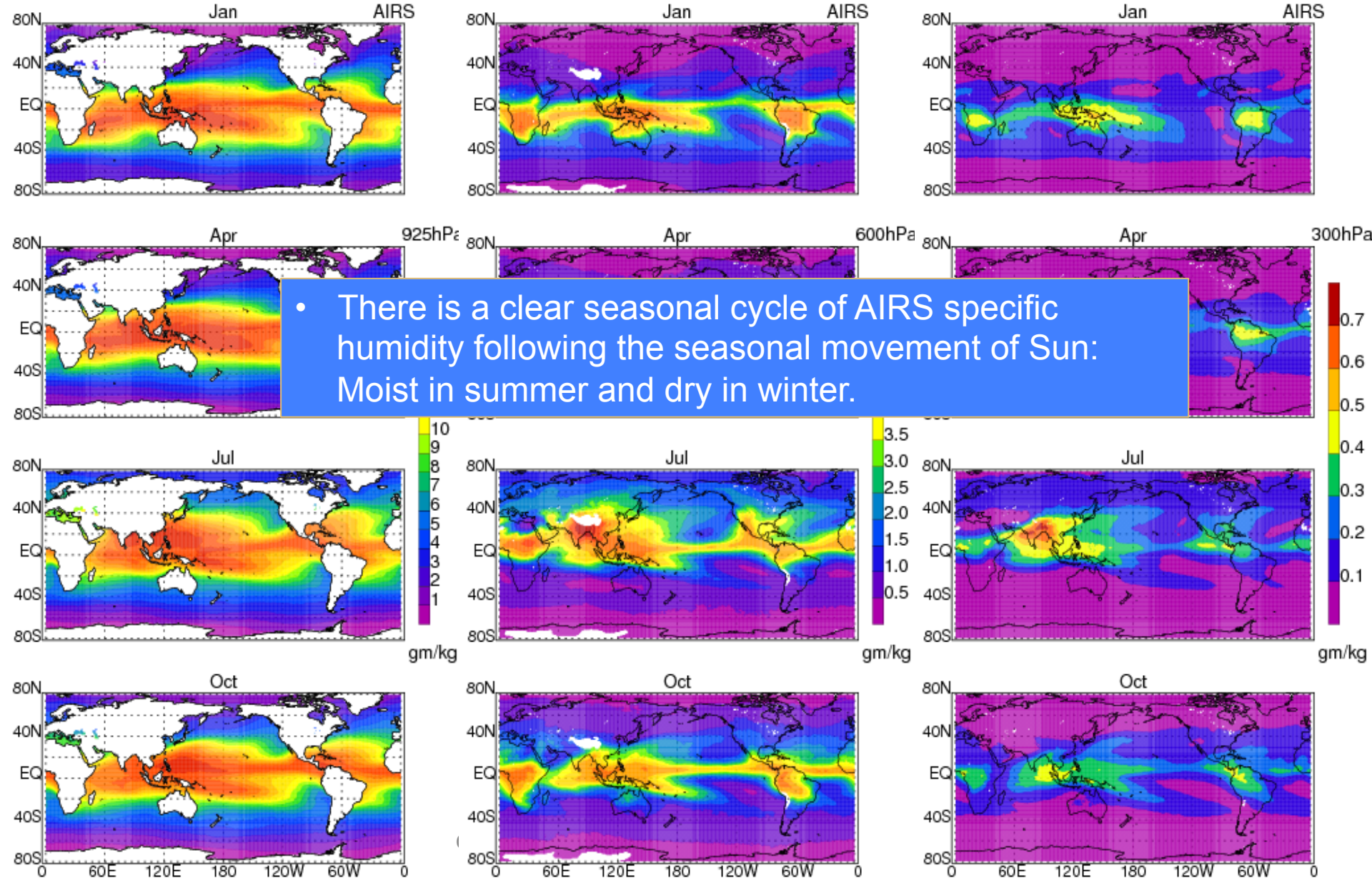


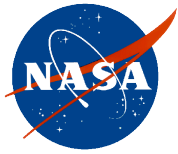


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AIRS Water Vapor Seasonal Cycle



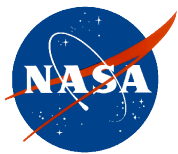


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CMIP5 Model Evaluation



CMIP5 Simulations

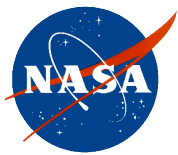
Table 3. Baseline simulations for model evaluation and for understanding historical and paleoclimates. Taylor et al. (2009).

| # | Experiment | Notes | # of years |
|-----|--------------------------------------|---|------------|
| 3.2 | Historical (1850 – at least 2005) | Impose changing conditions (consistent with observations), which may include: <ul style="list-style-type: none">• atmospheric composition (including CO₂), due to both anthropogenic and volcanic influences• solar forcing• emissions or concentrations of short-lived species and natural and anthropogenic aerosols or their precursors.• land use | ≥156 |

The purpose of historical experiment:

(a) Evaluate model performance against present climate and observed climate change.

Focus on the last 20 years (1986 – 2005)



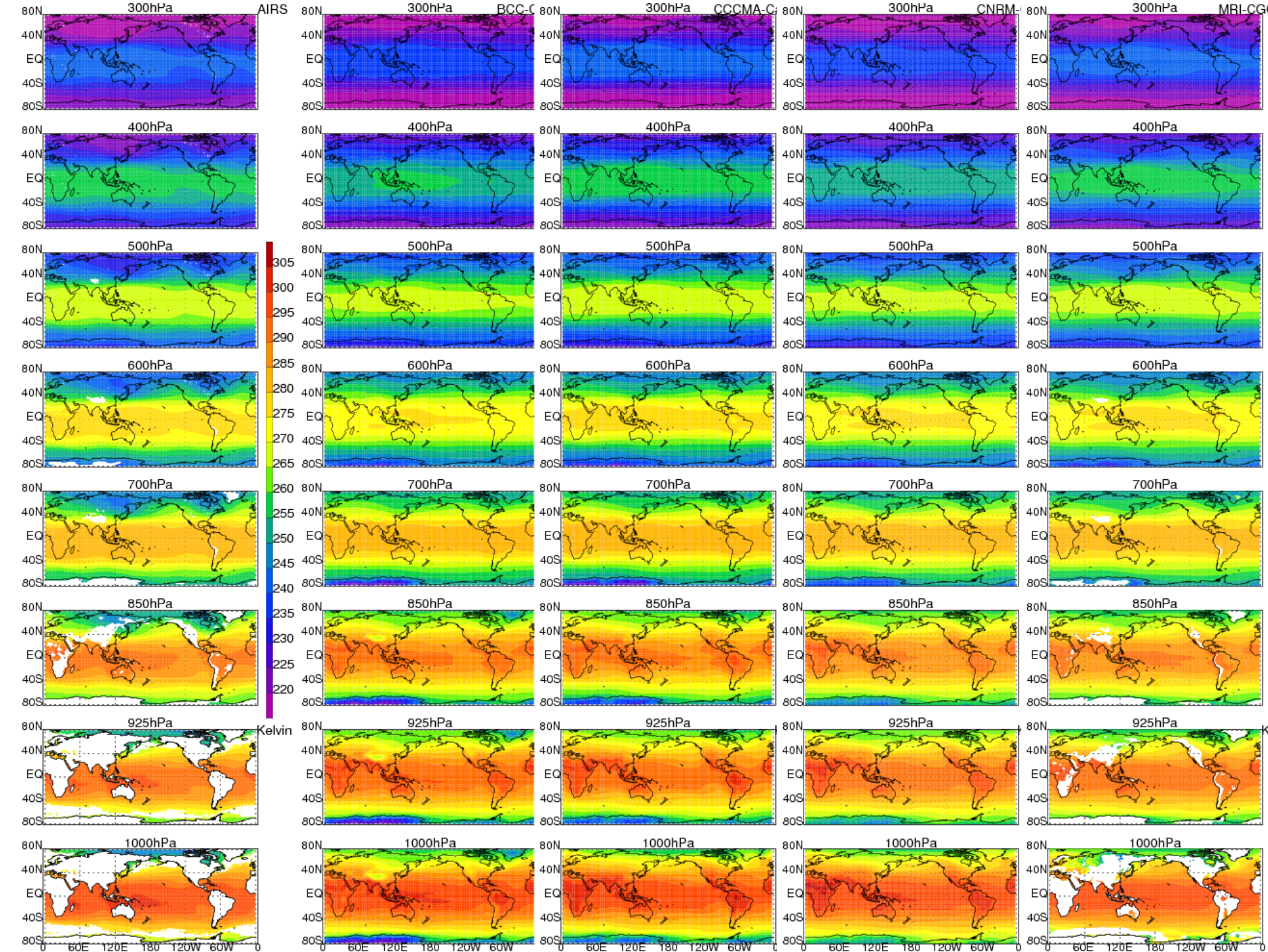
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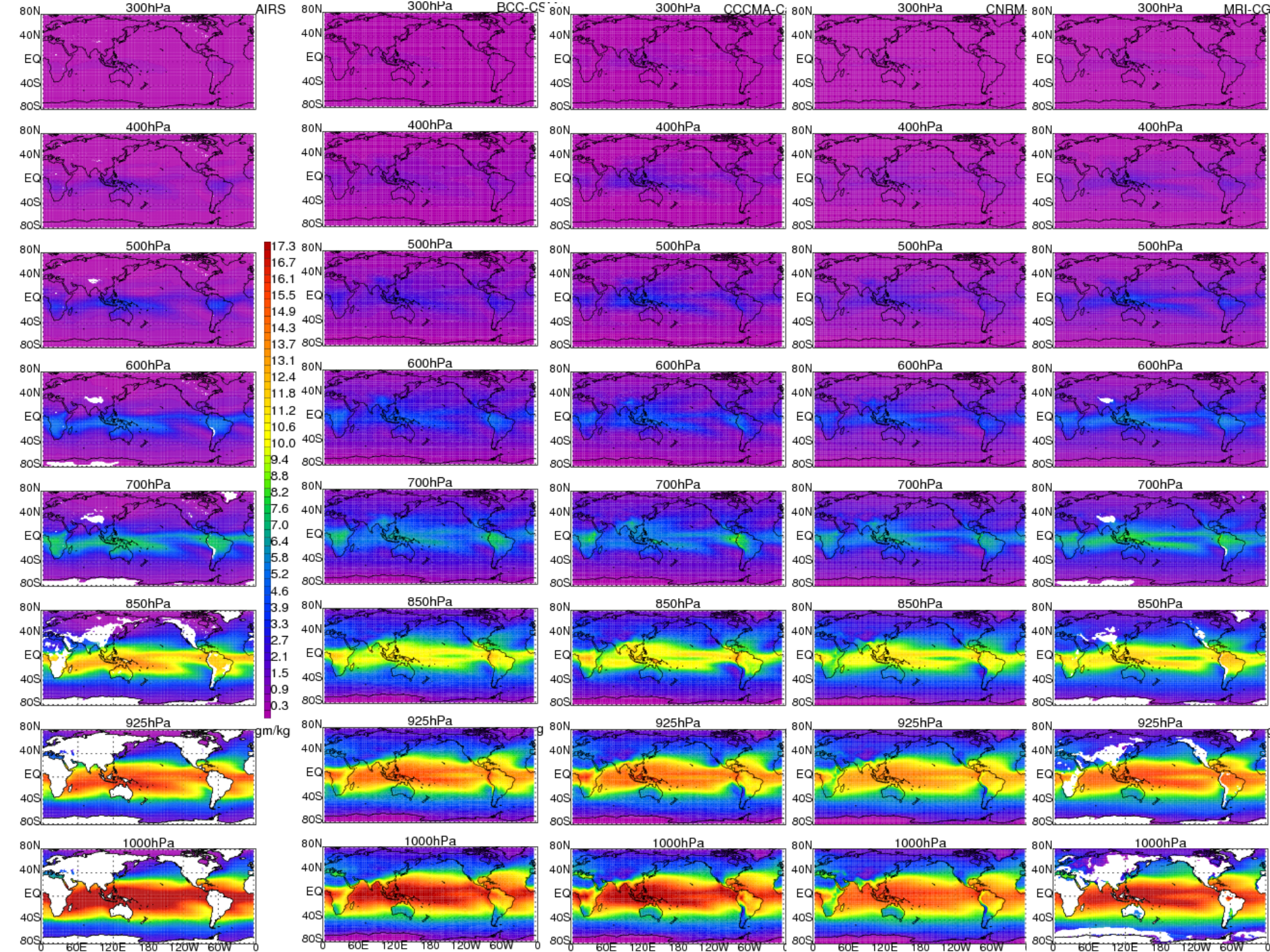
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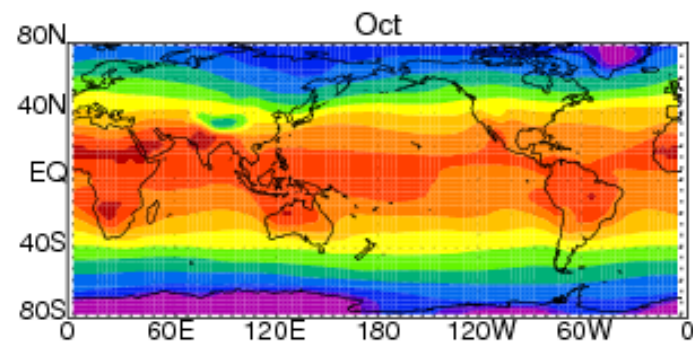
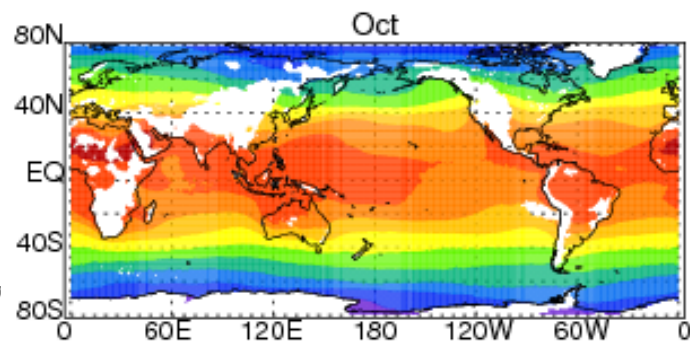
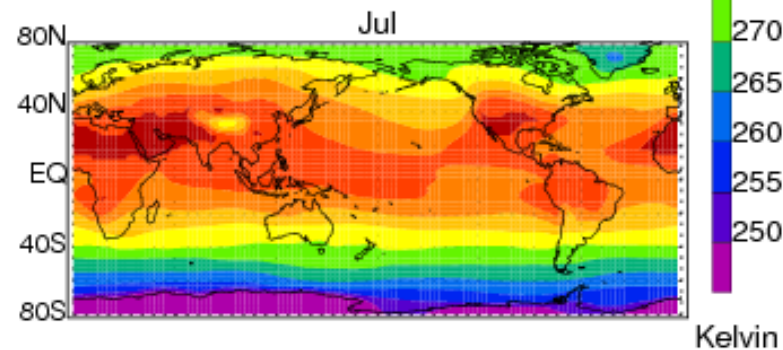
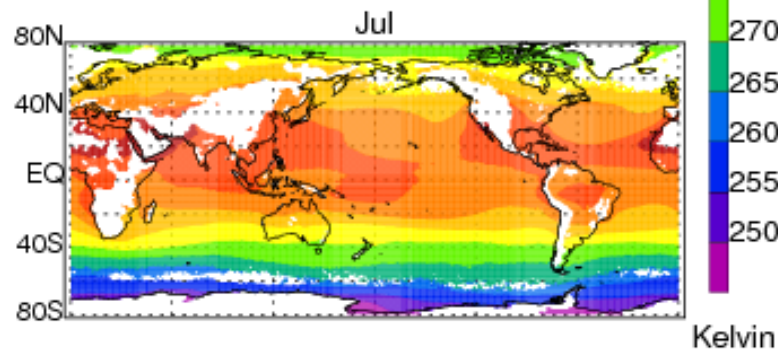
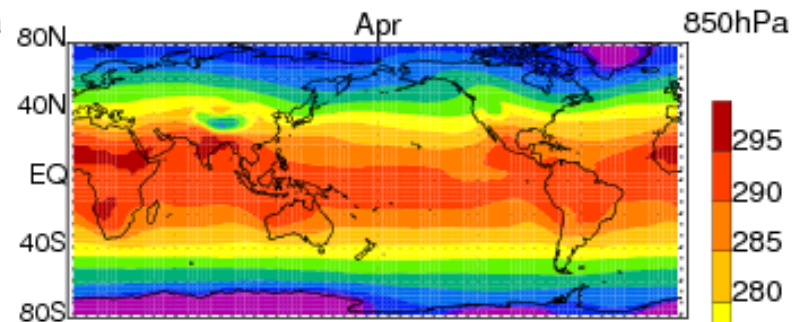
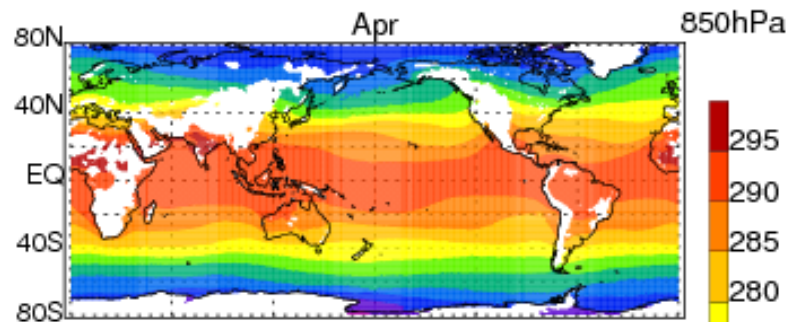
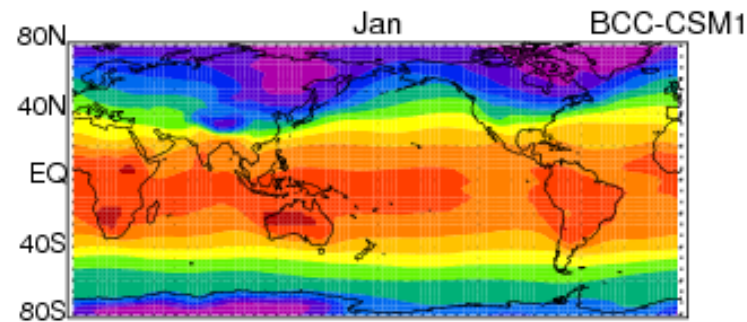
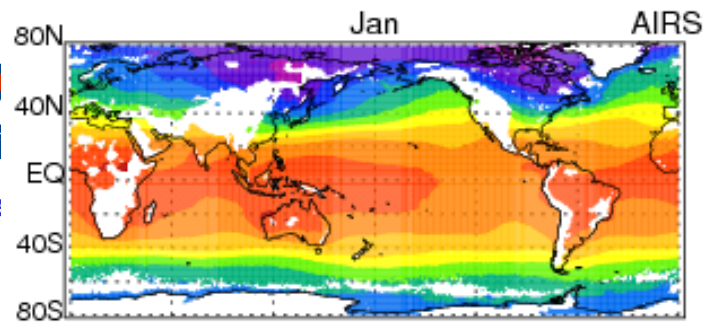
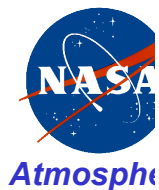
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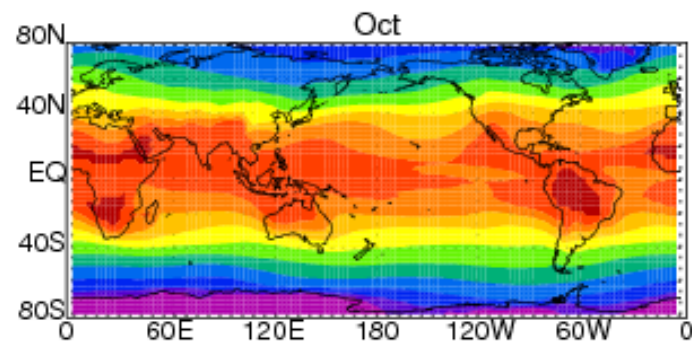
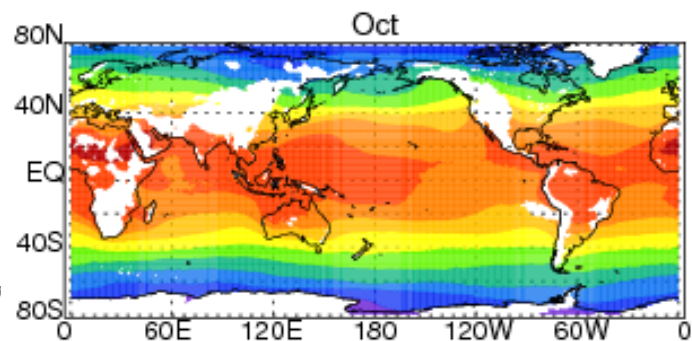
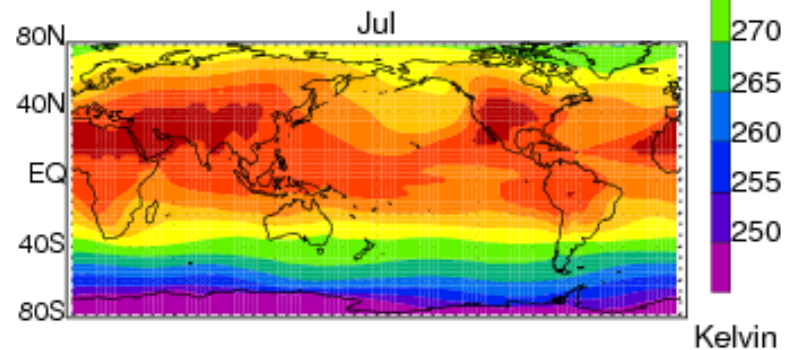
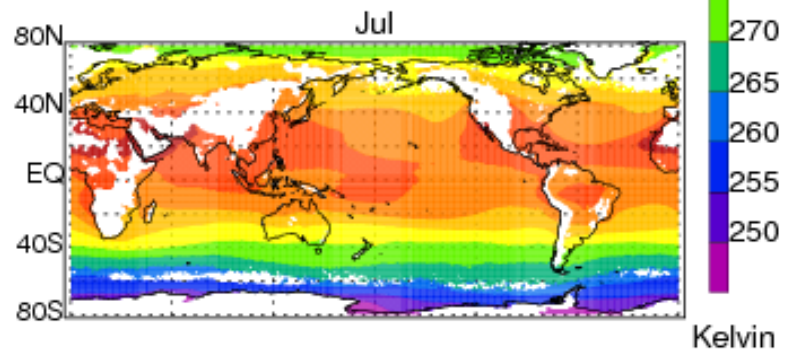
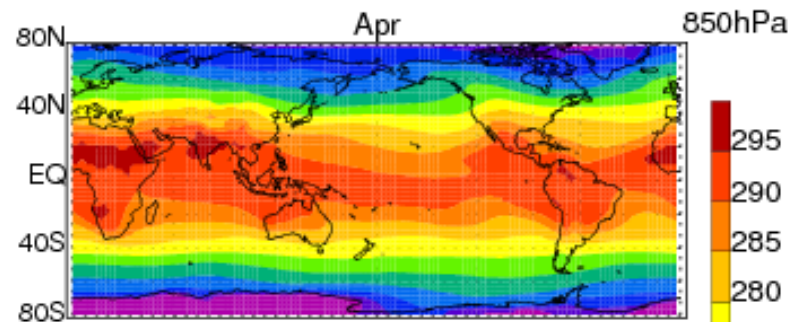
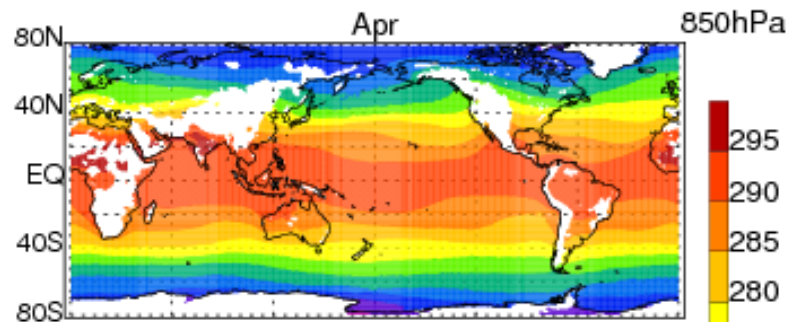
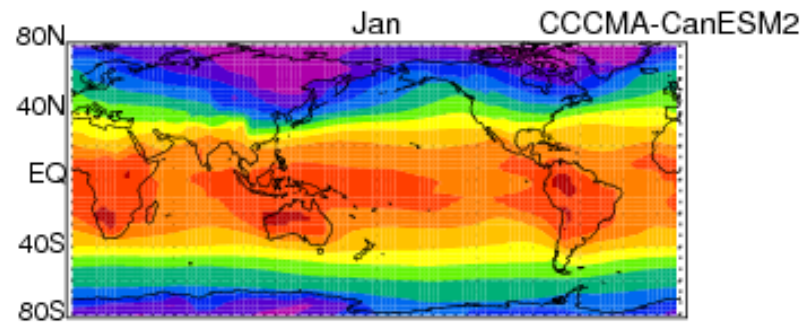
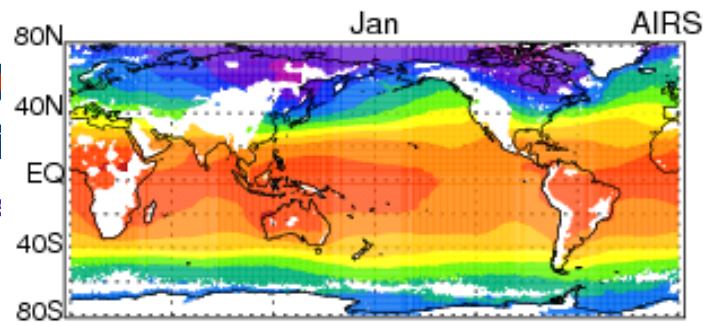
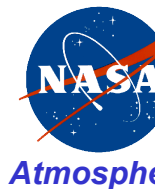
CMIP5 Models

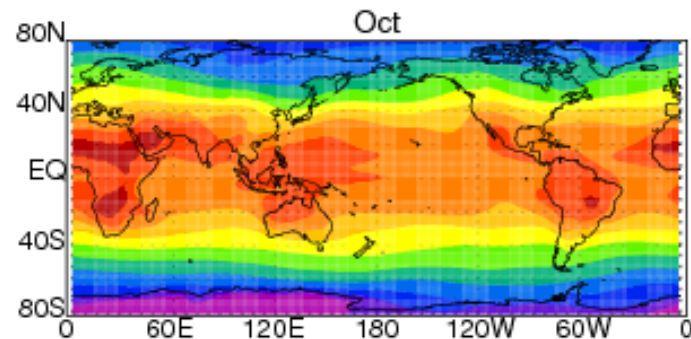
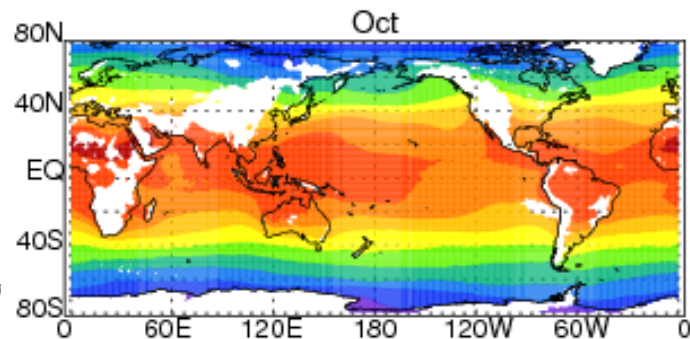
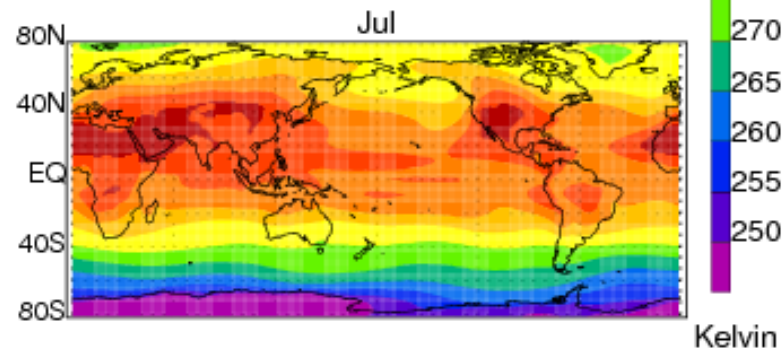
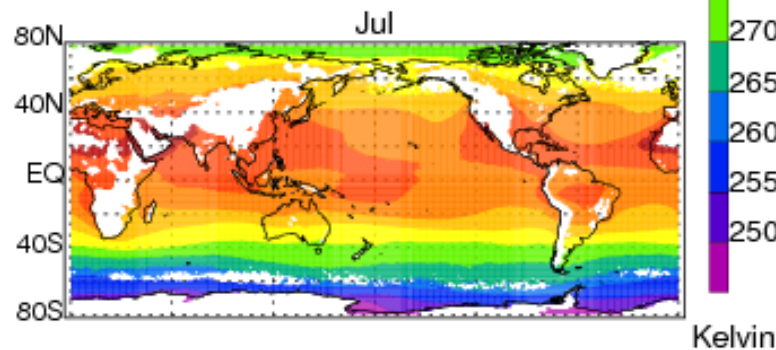
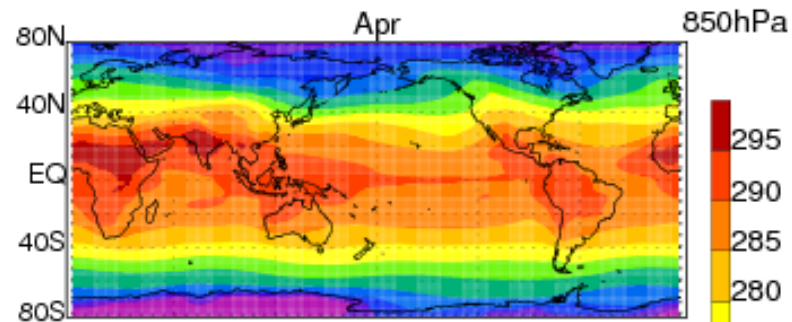
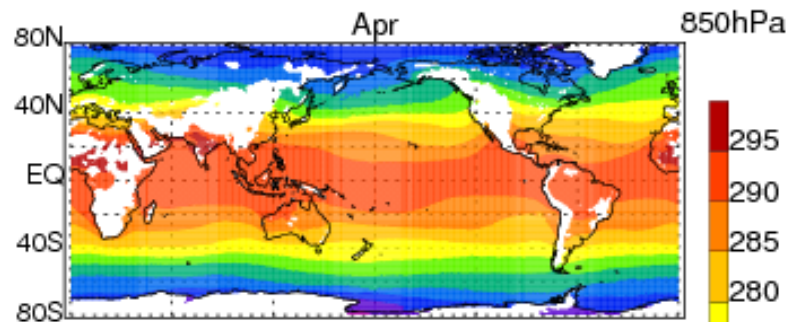
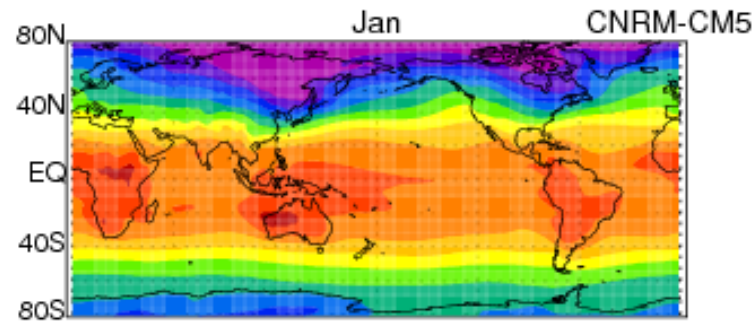
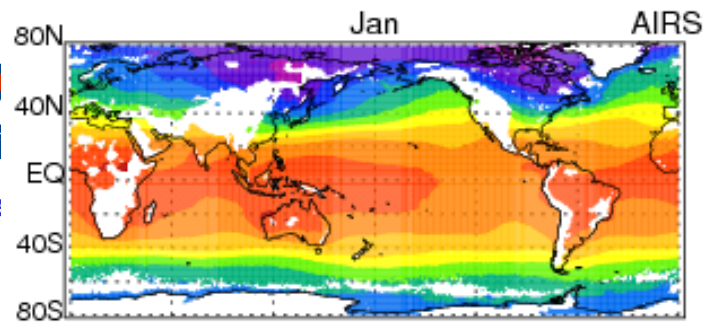
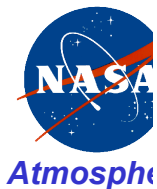
| # | Institution | Name | Type | Horizontal Resolution | Vertical Resolution | Reference |
|---|---|-------------------|-------|-----------------------|--|---------------------------|
| 1 | Beijing Climate Center (BCC), China | BCC-CSM1.1 | ESM | 2.8°X2.8° (T42) | 17 standard pressure levels (L26) | Wu et al. (2011) |
| 2 | Canadian Center for Climate Modeling and Analysis (CCCma), Canada | CCCma- CanESM2 | ESM | 2.8°X2.8° (T63) | 22 pressure levels (17 std + 5 ext) (L35) | Arora et al. (2011) |
| 3 | National Centre for Meteorological Research (CNRM), France | CNRM- CM5.1 | AOGCM | 1.4°X1.4° (T127) | 17 standard pressure levels (L31) | Voldoire et al. (2011) |
| 4 | Meteorological Research Institute (MRI), Japan | MRI-CGCM3 | AOGCM | 1.1°X1.1° (T159) | 23 pressure levels (17 std + 6 ext) (L48) | Yukimoto et al. (2011) |

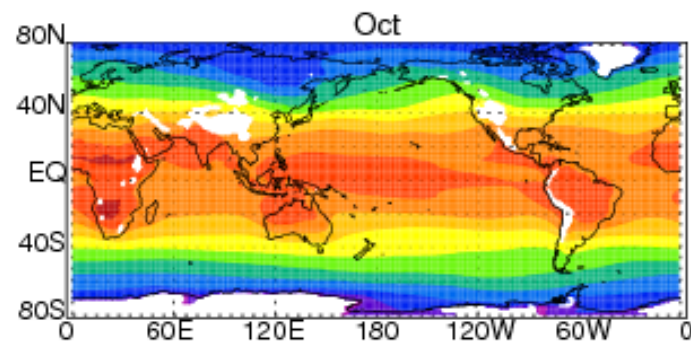
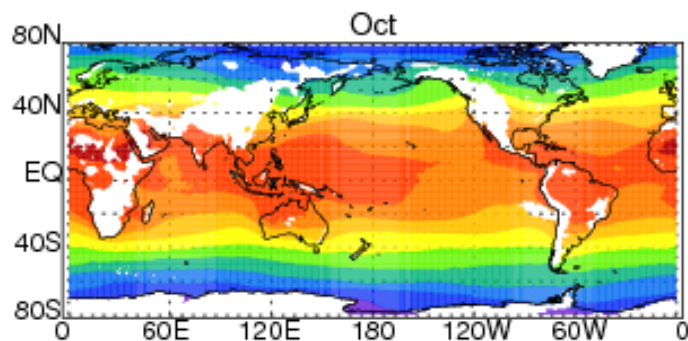
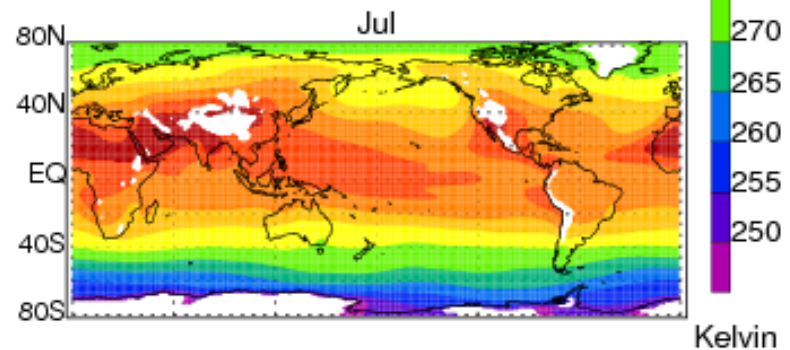
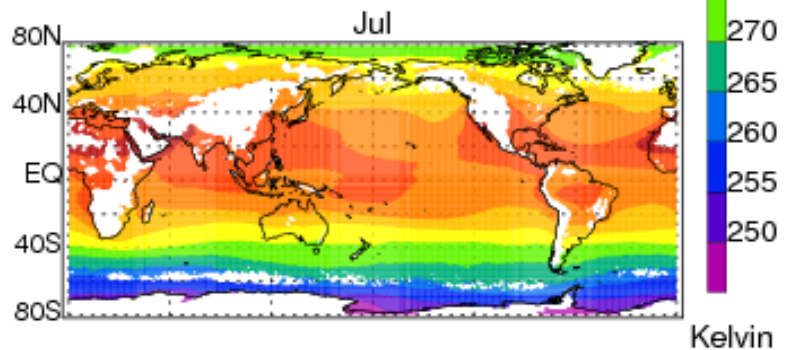
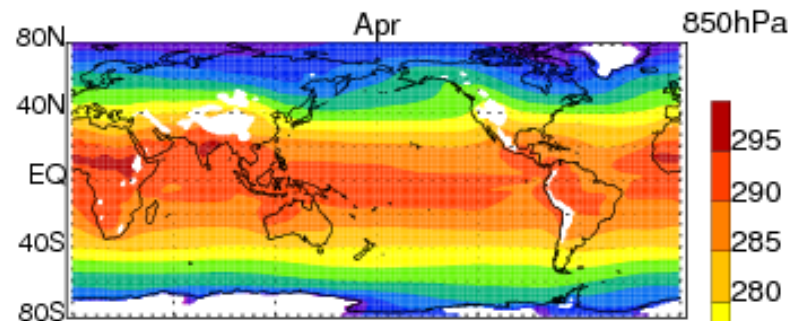
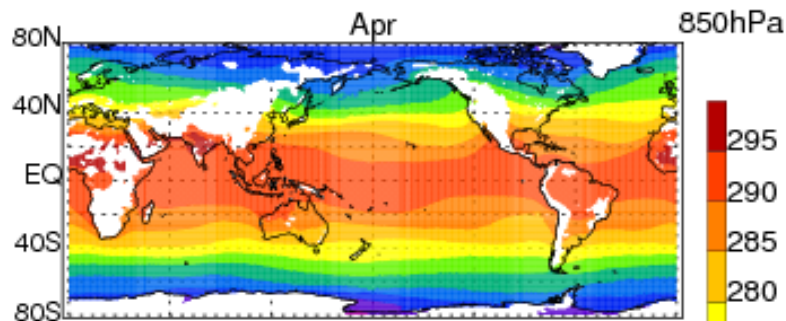
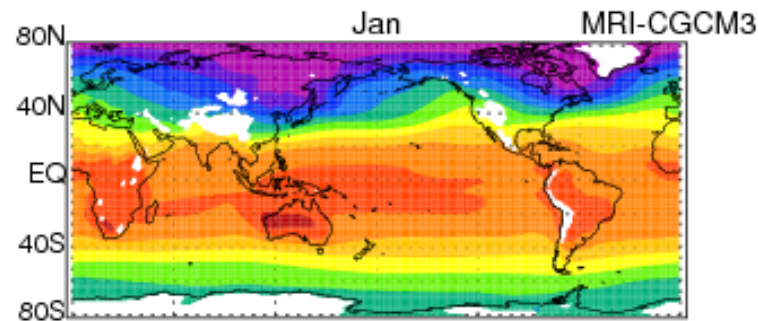
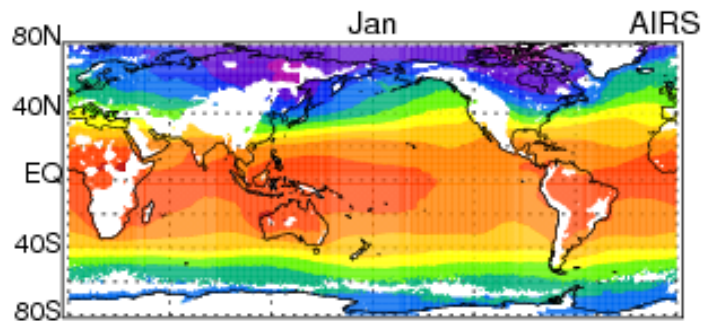
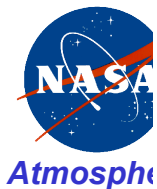


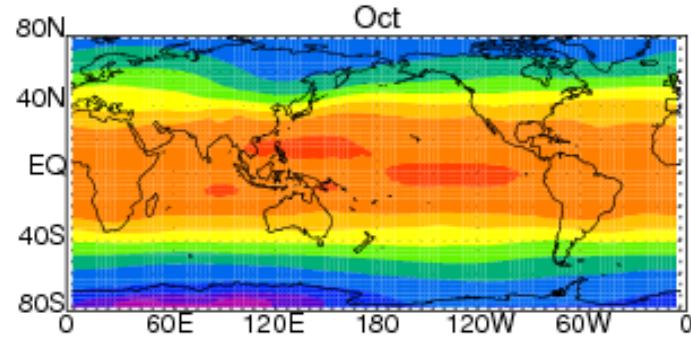
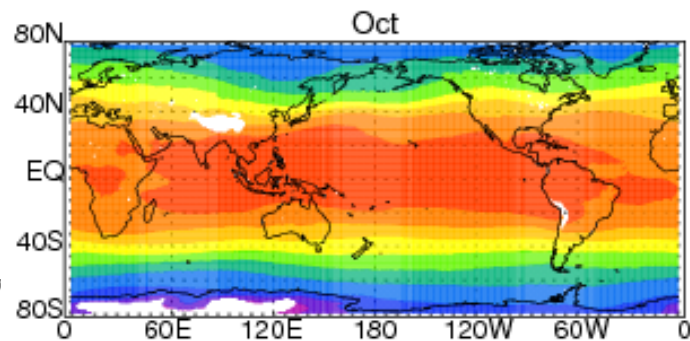
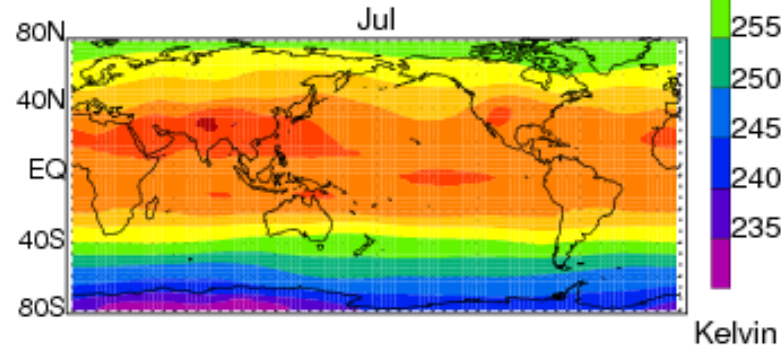
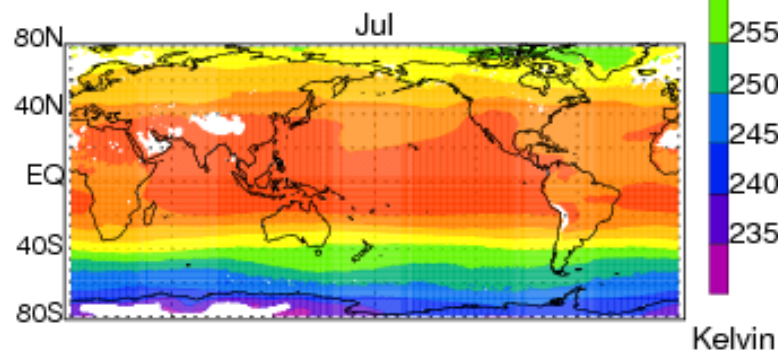
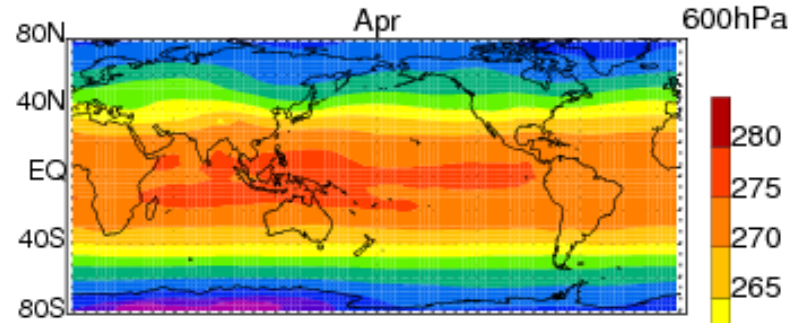
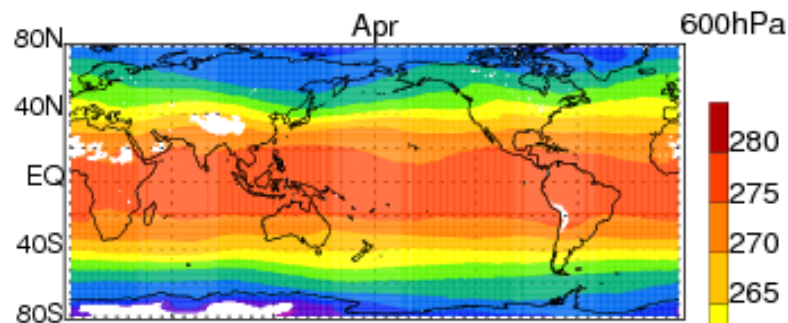
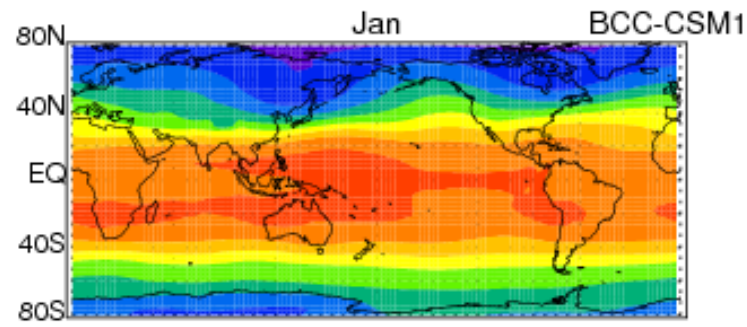
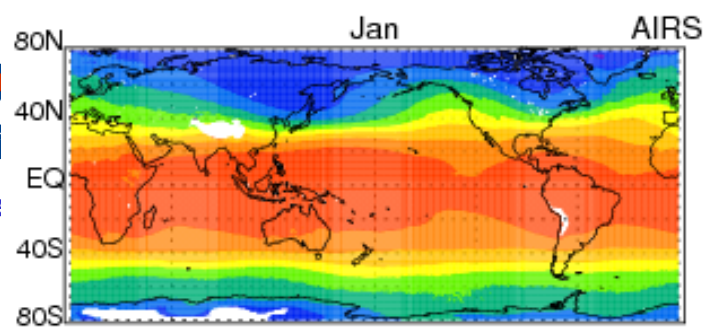


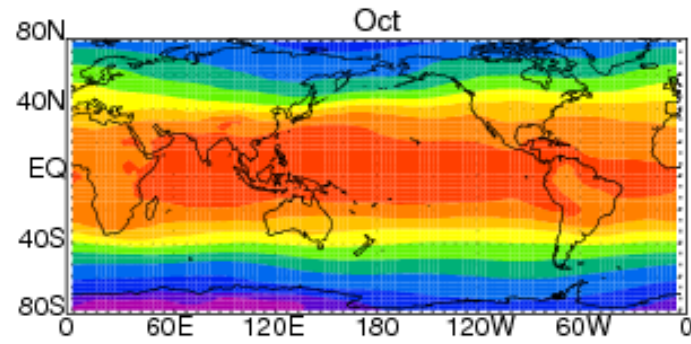
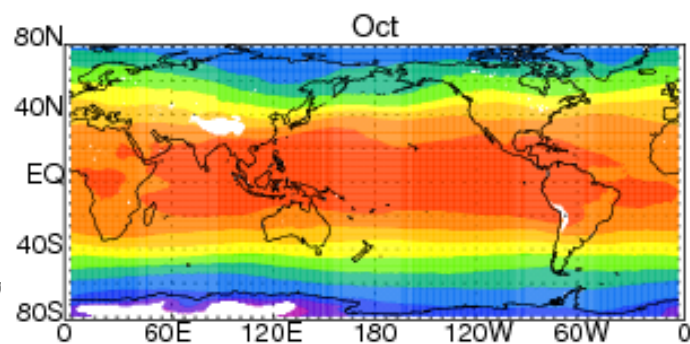
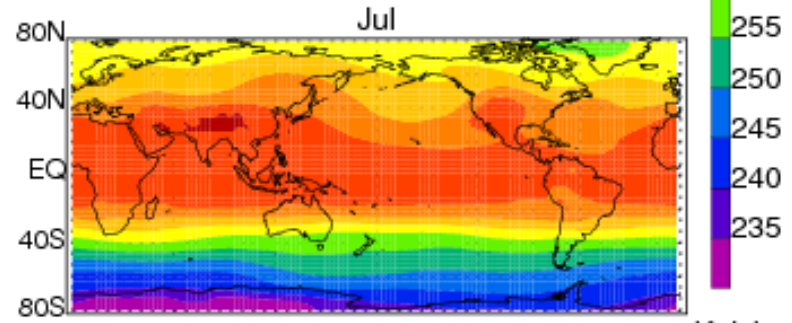
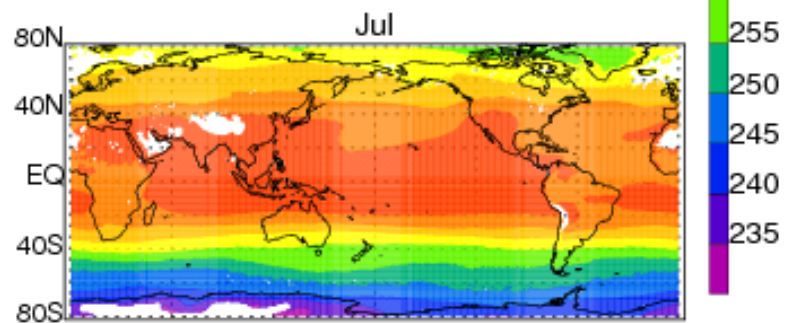
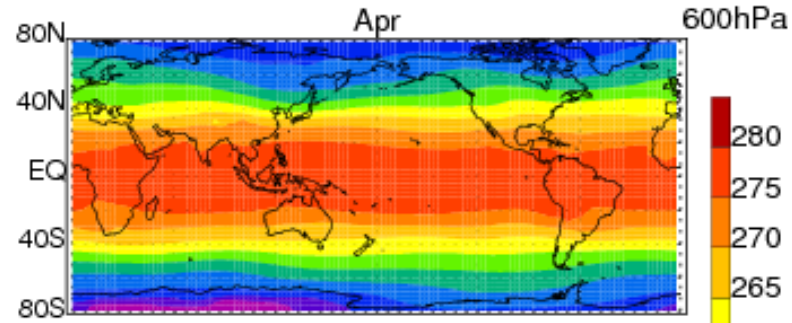
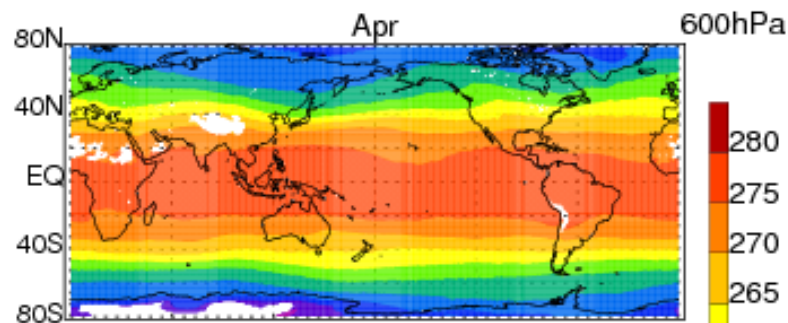
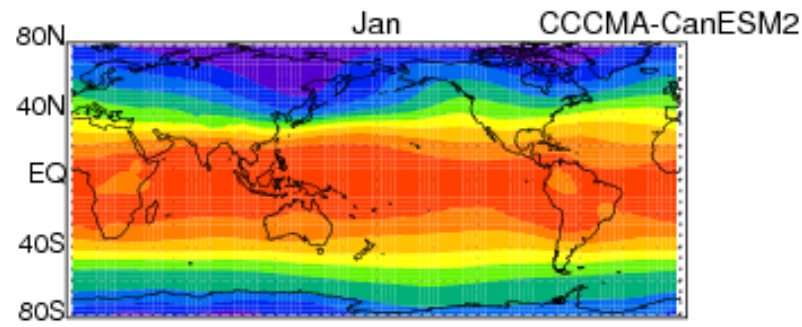
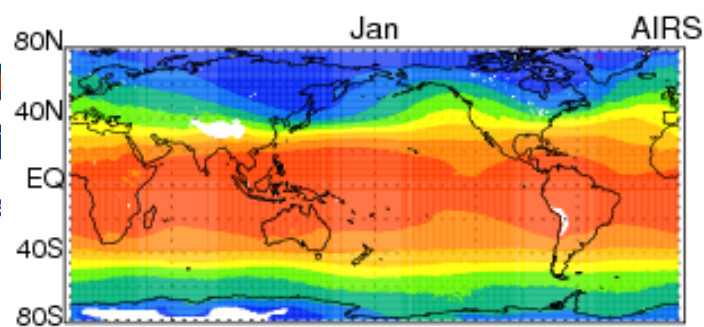


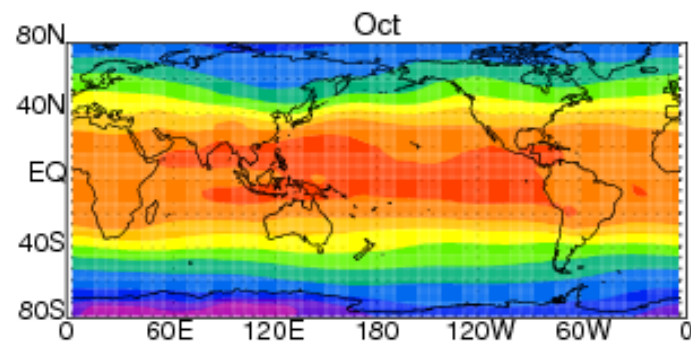
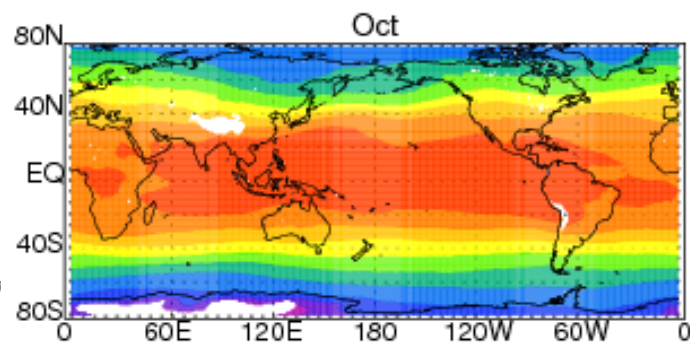
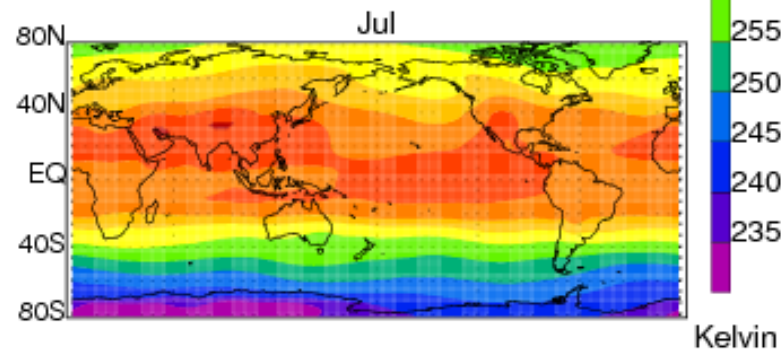
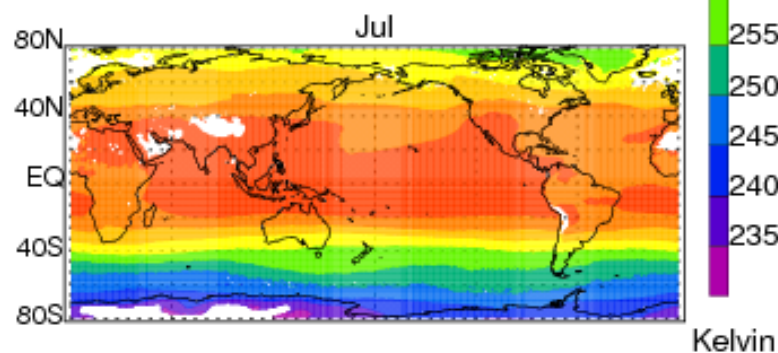
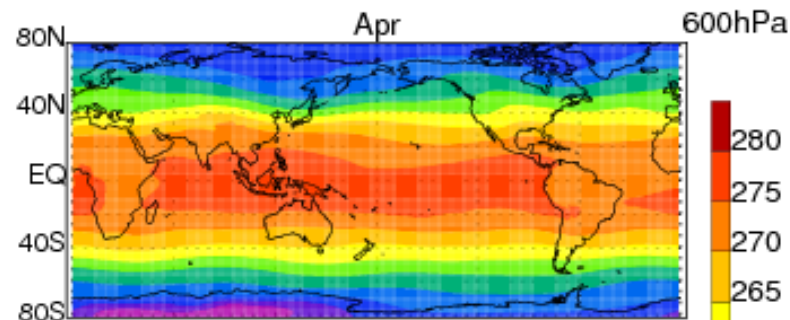
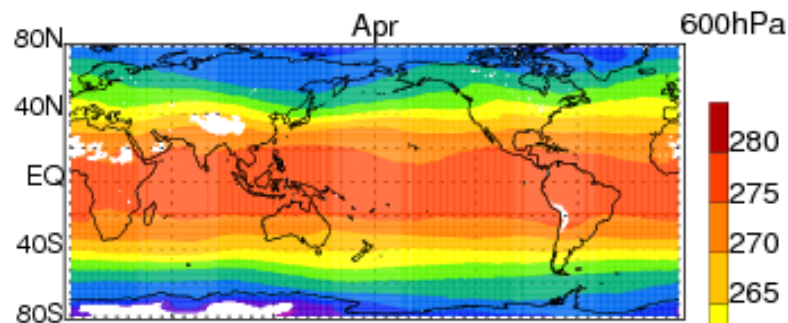
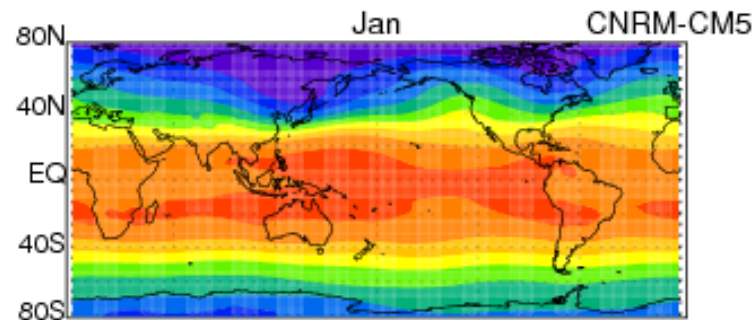
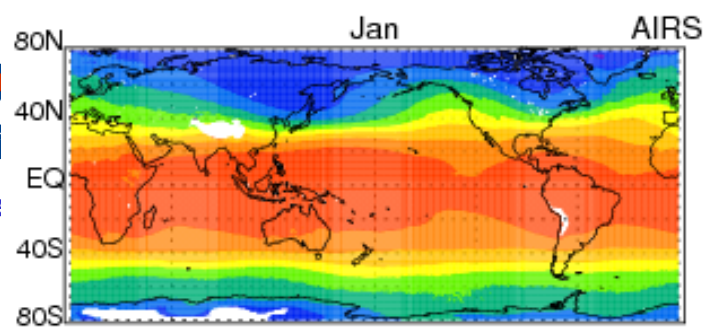
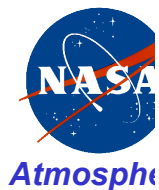


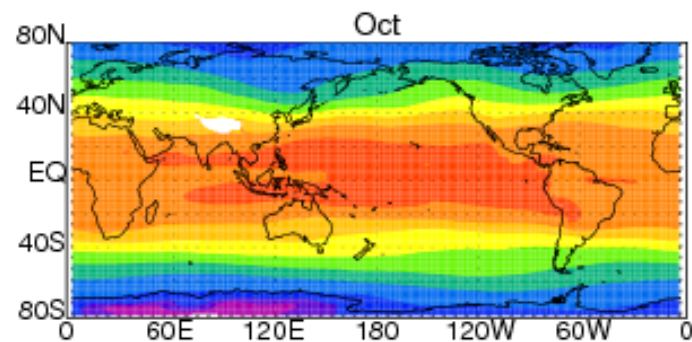
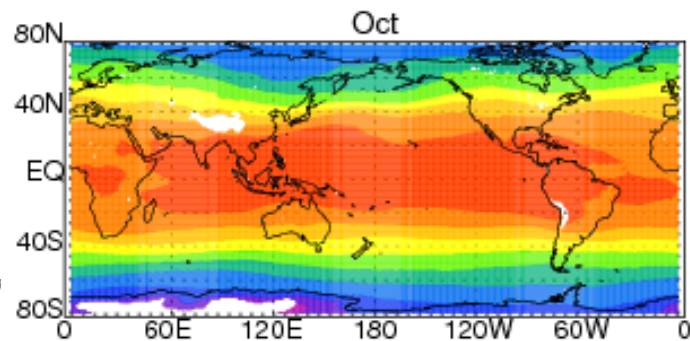
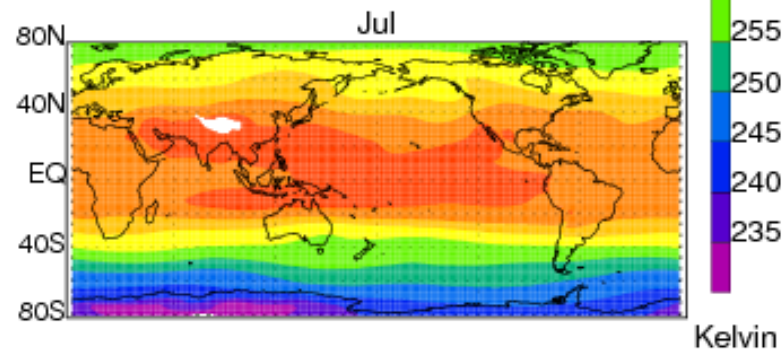
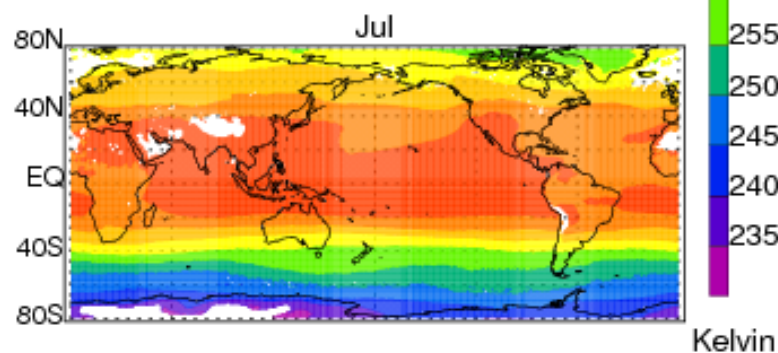
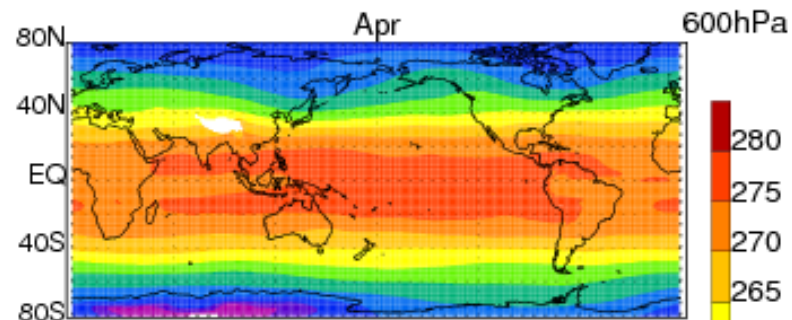
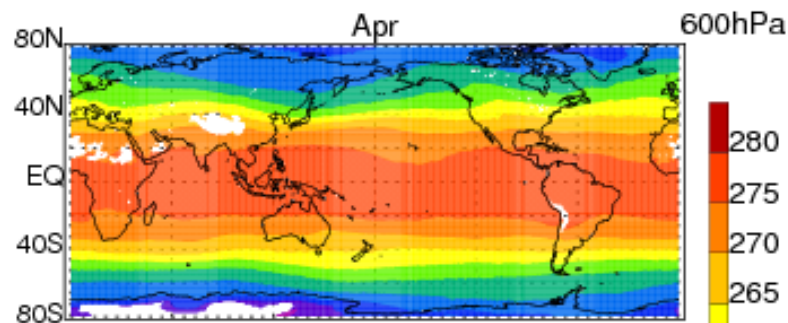
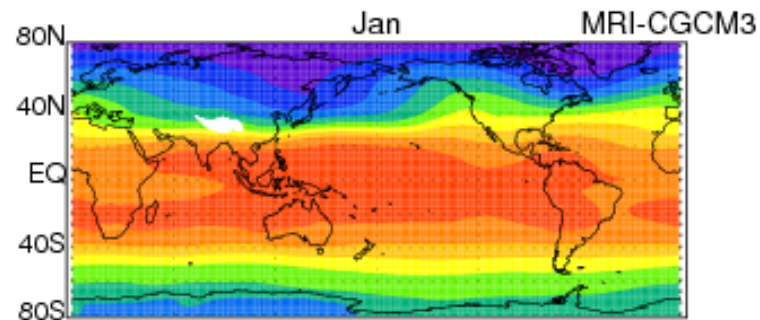
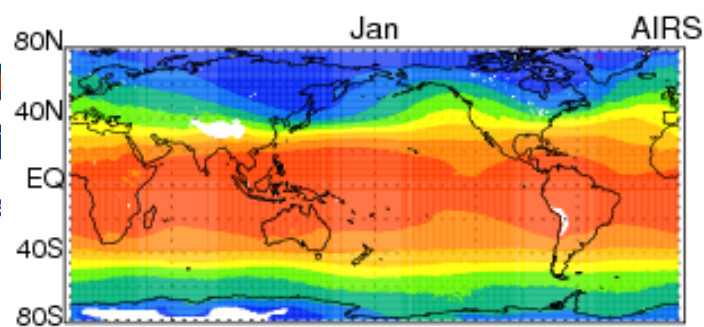
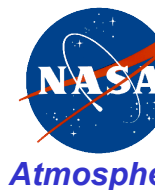


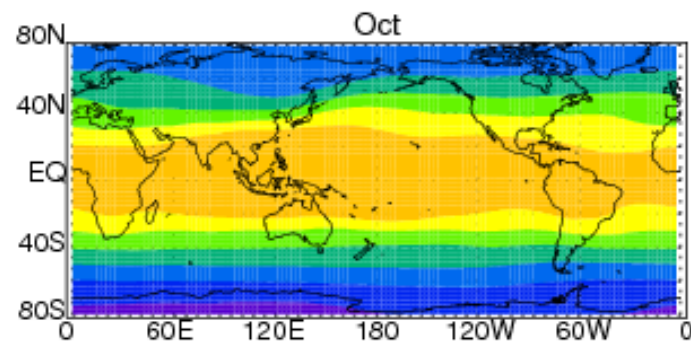
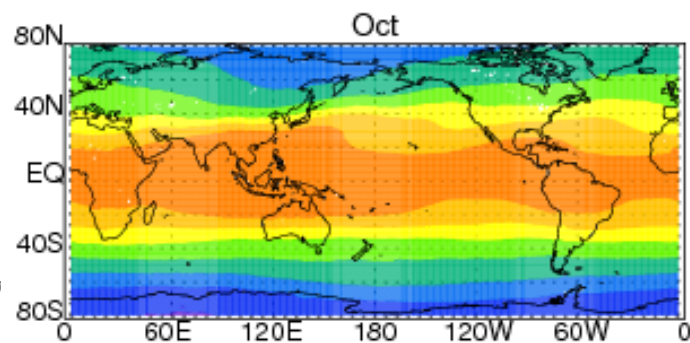
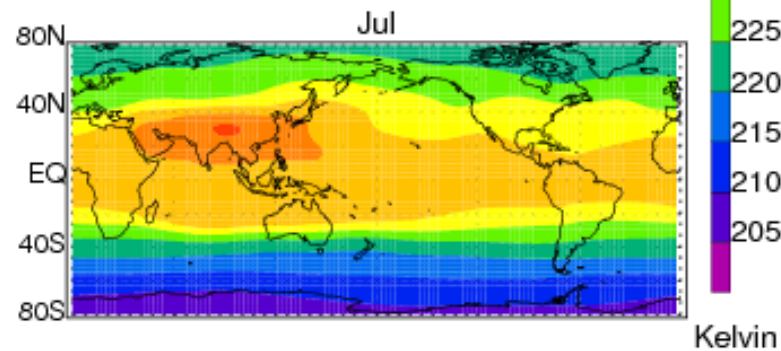
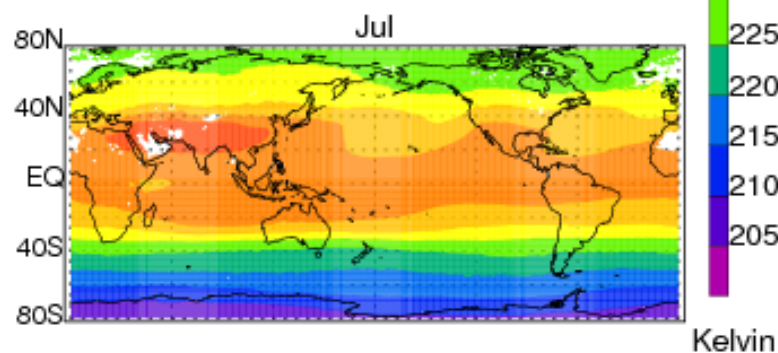
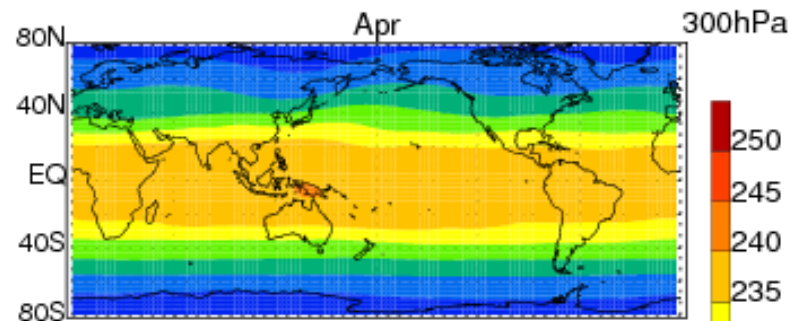
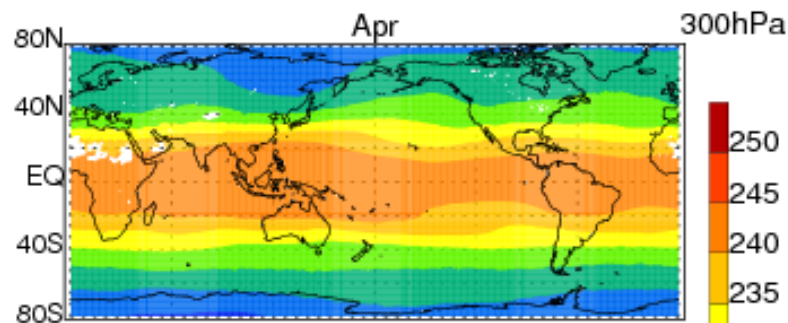
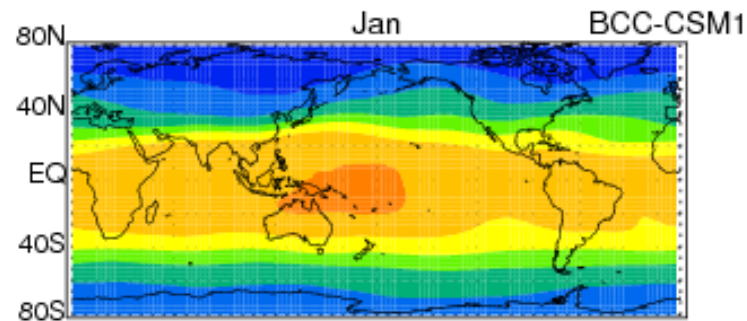
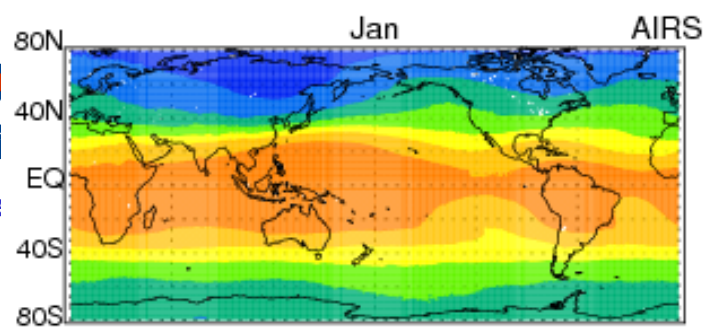
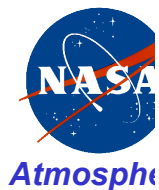


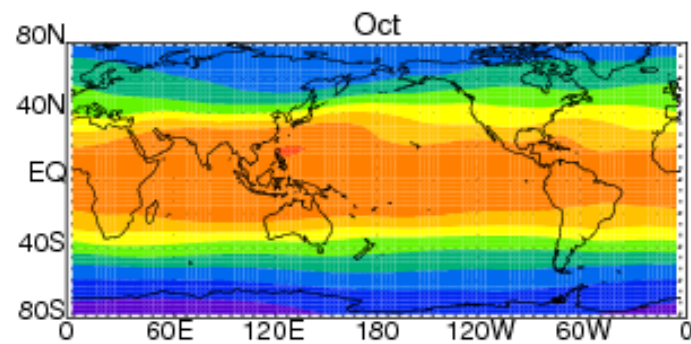
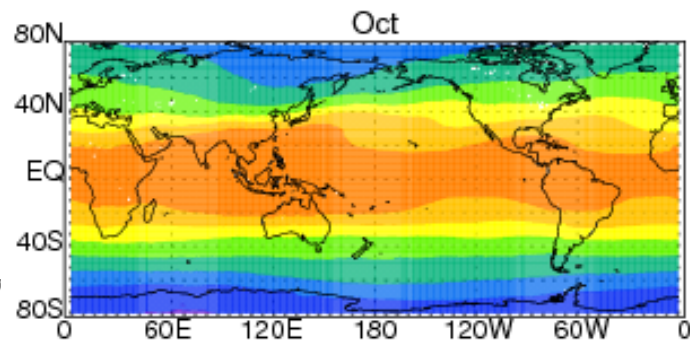
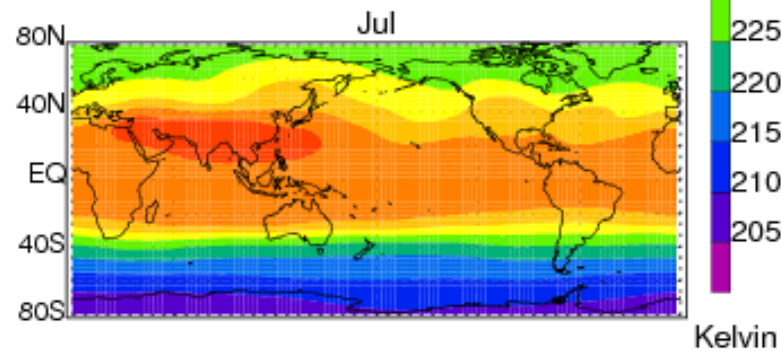
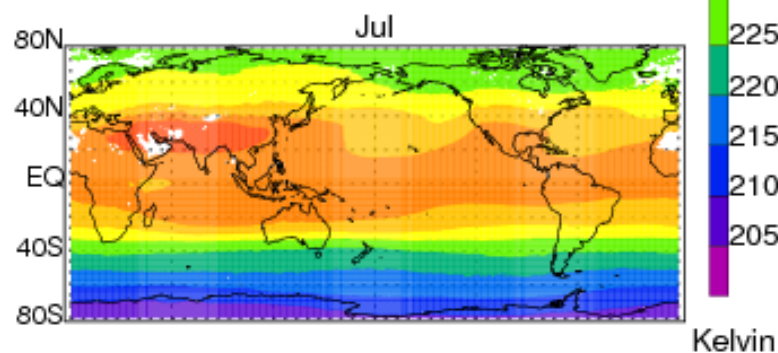
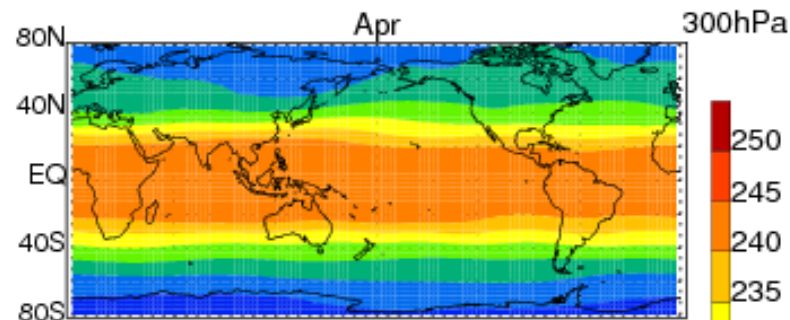
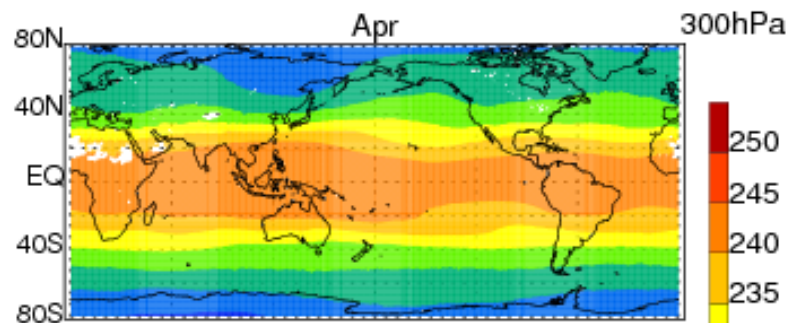
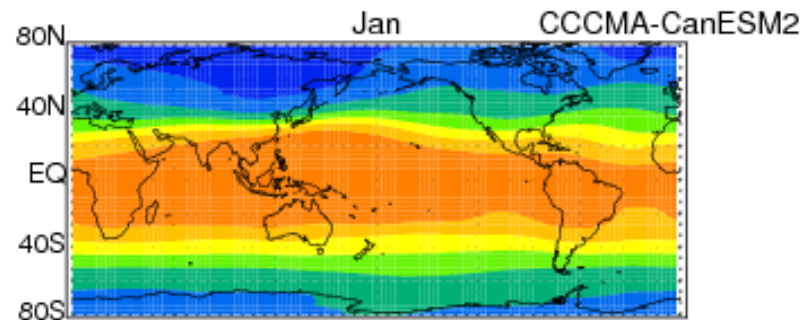
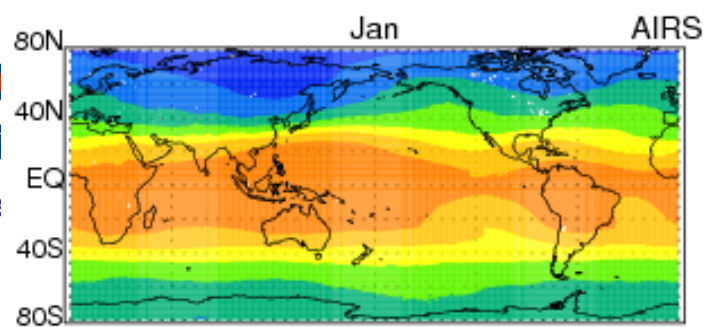
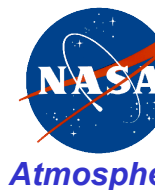


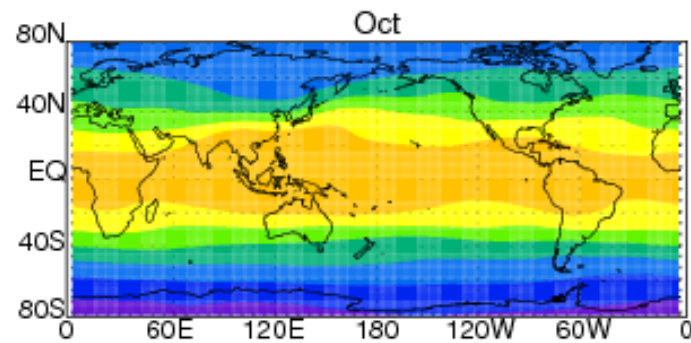
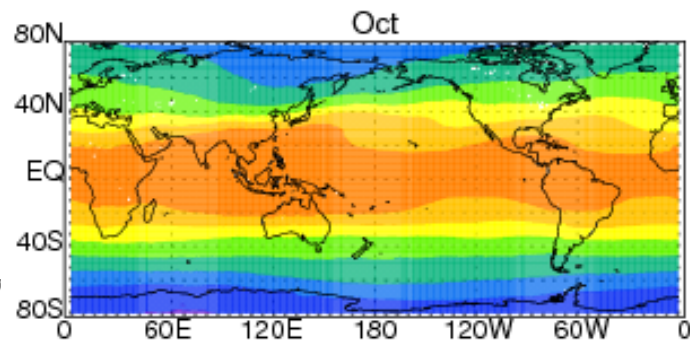
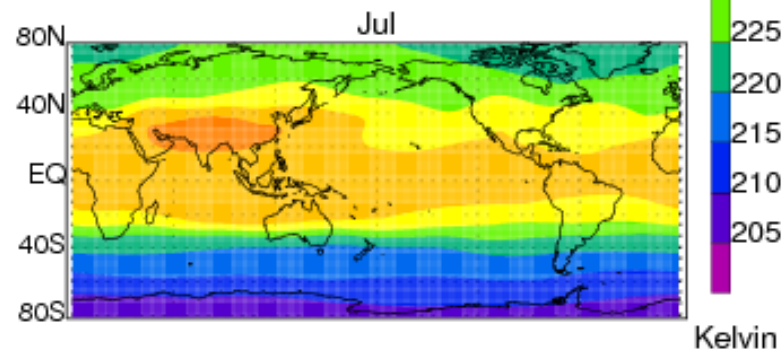
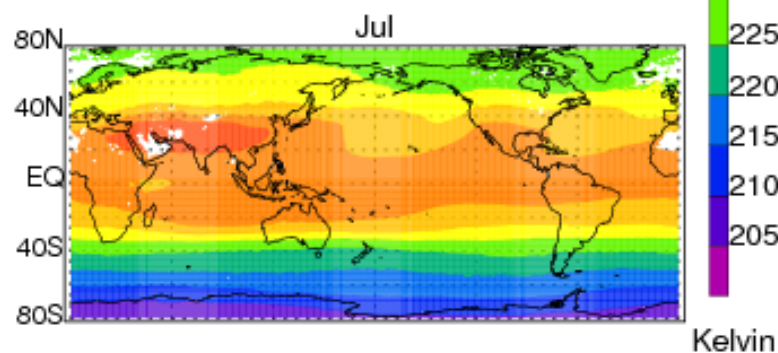
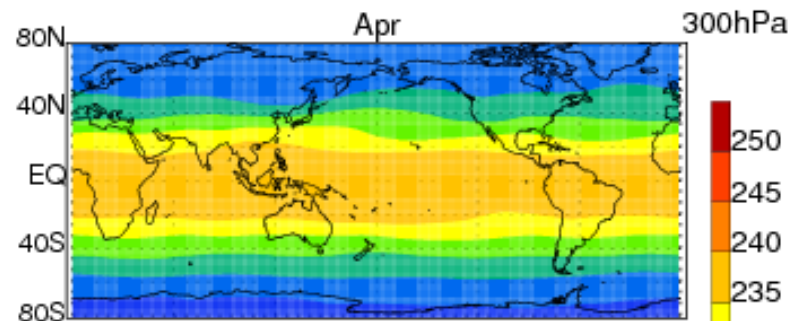
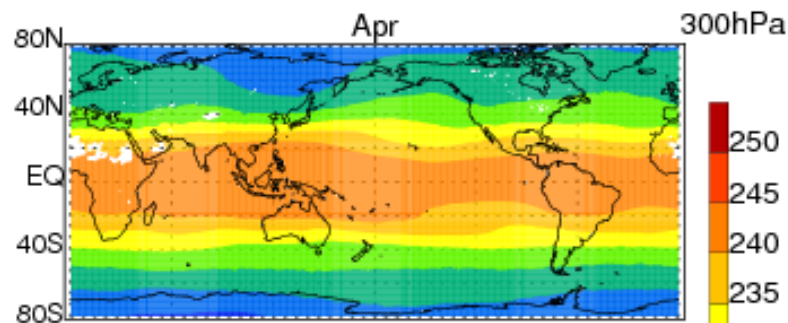
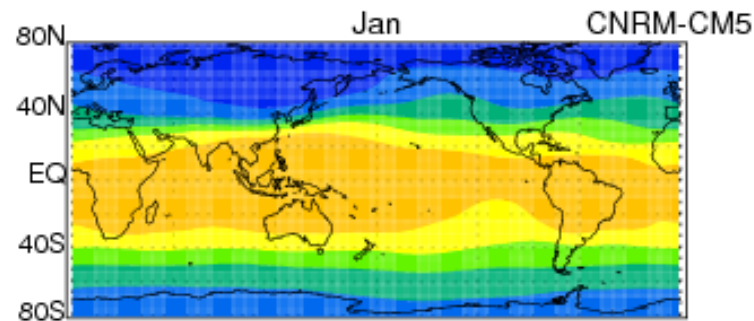
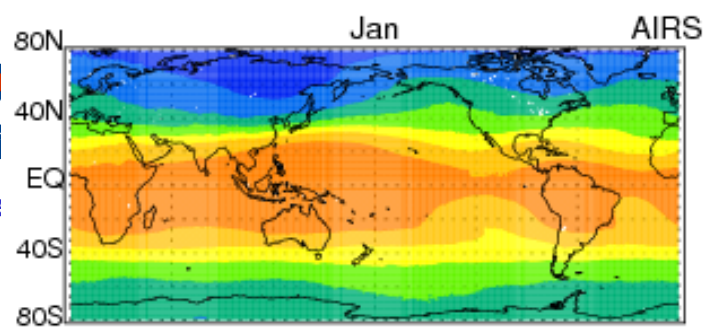
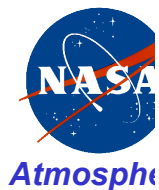


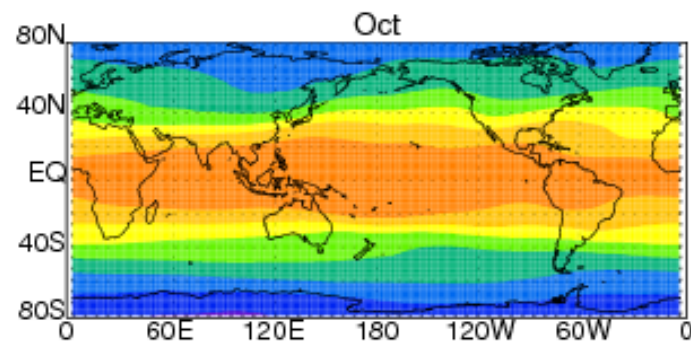
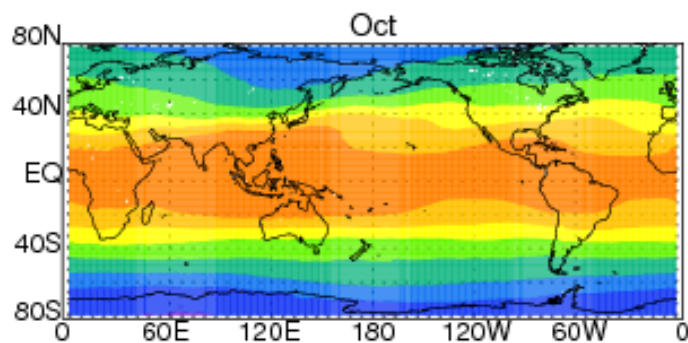
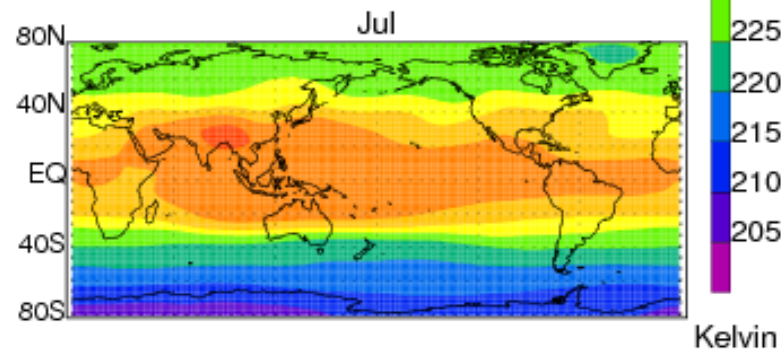
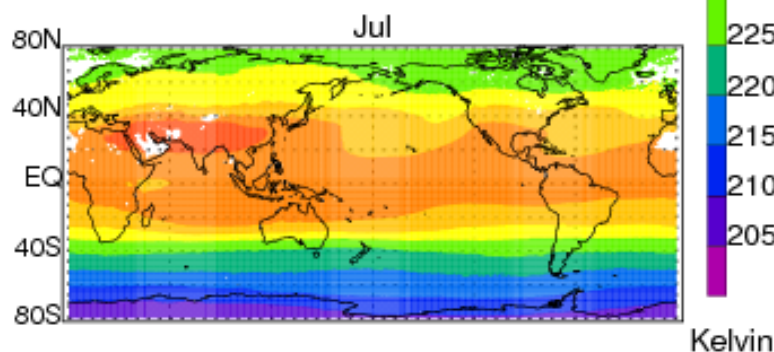
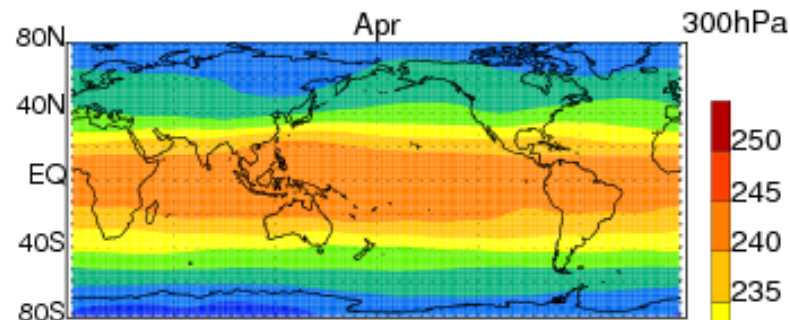
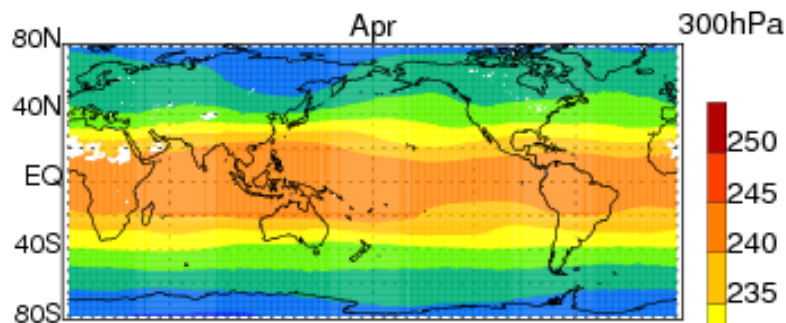
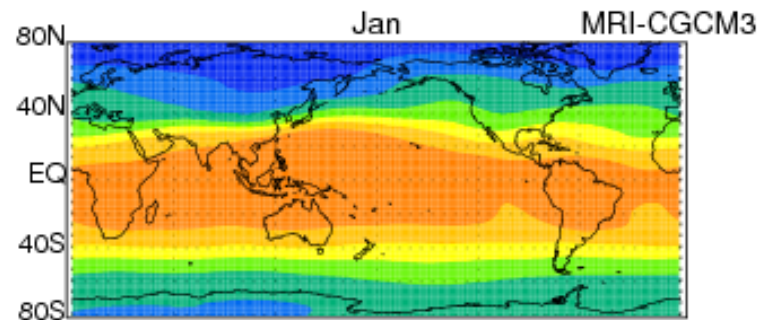
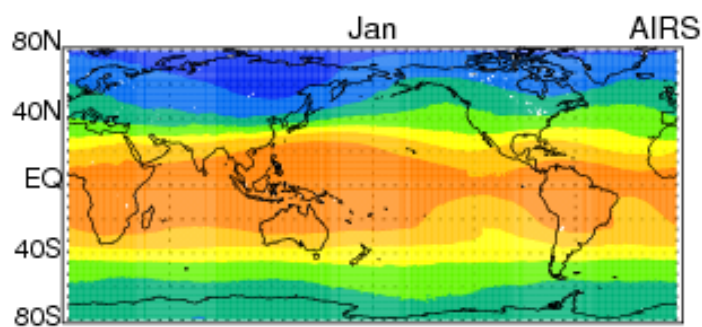
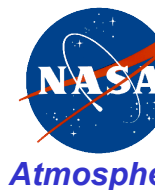






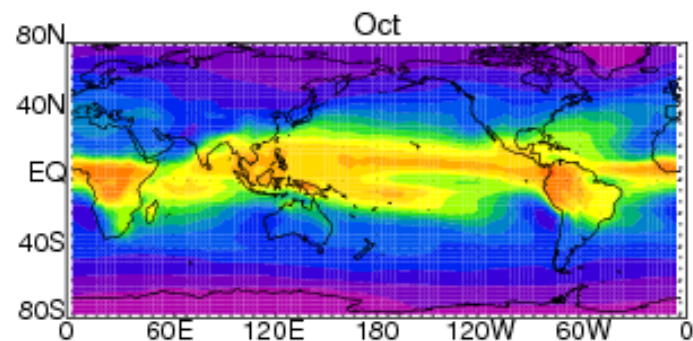
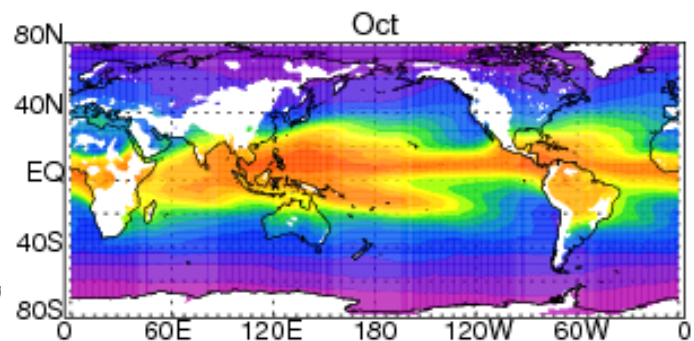
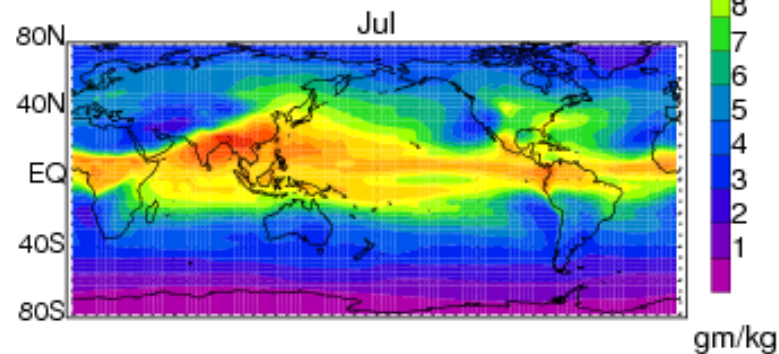
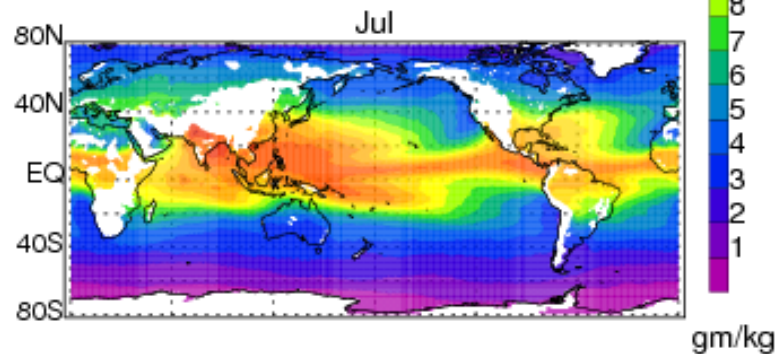
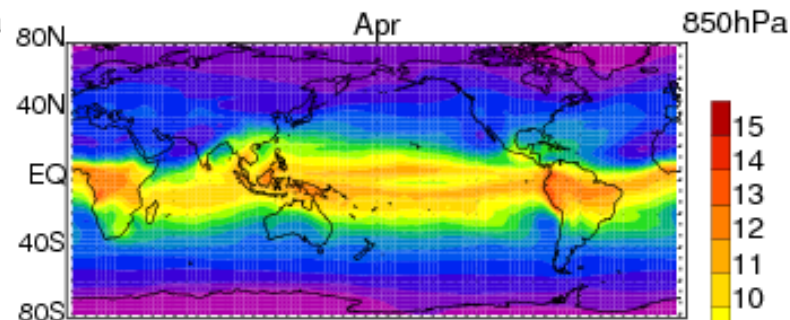
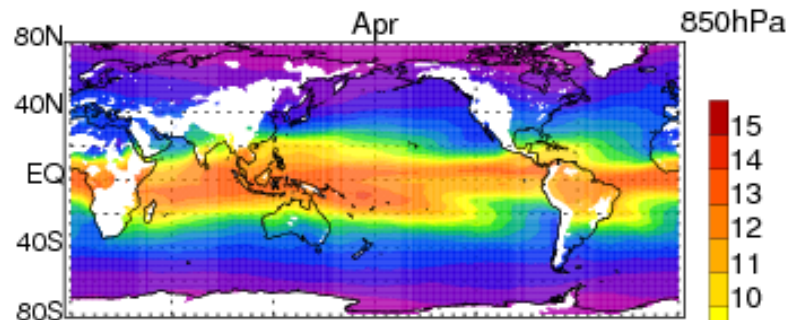
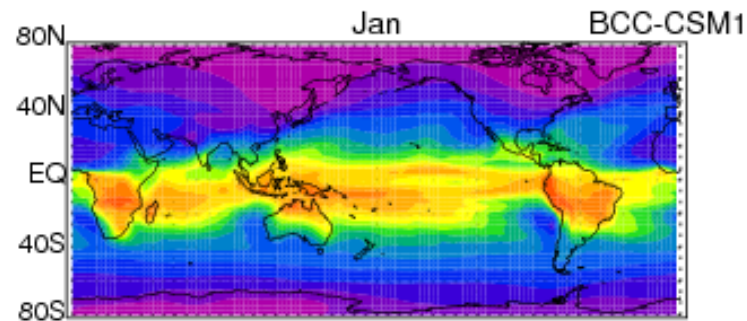
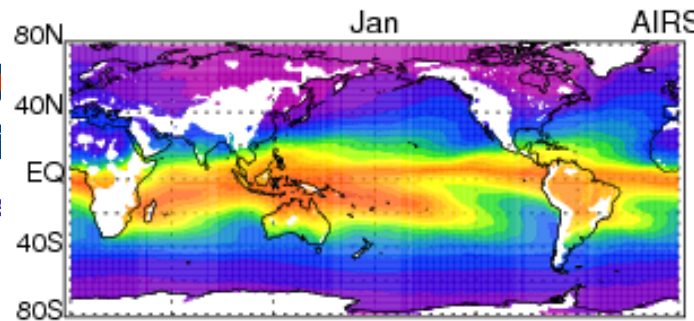
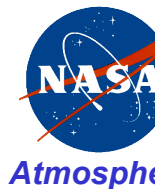


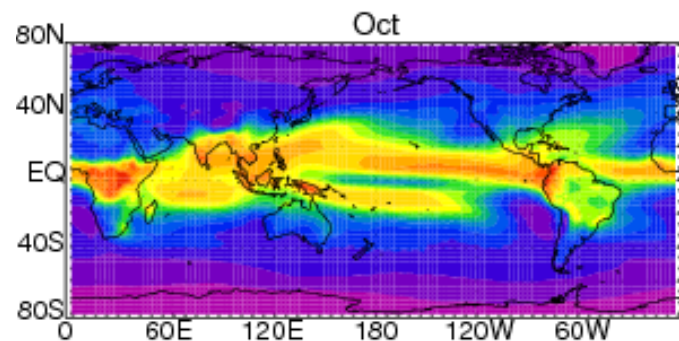
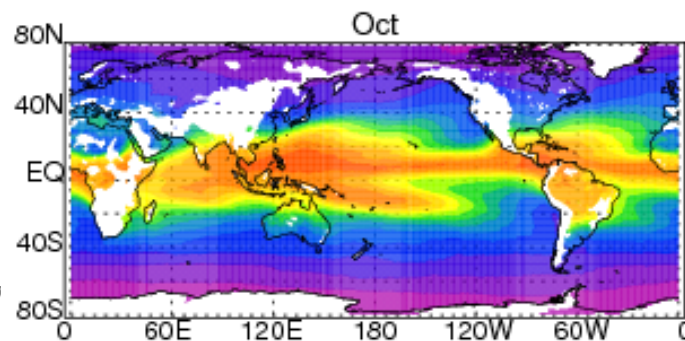
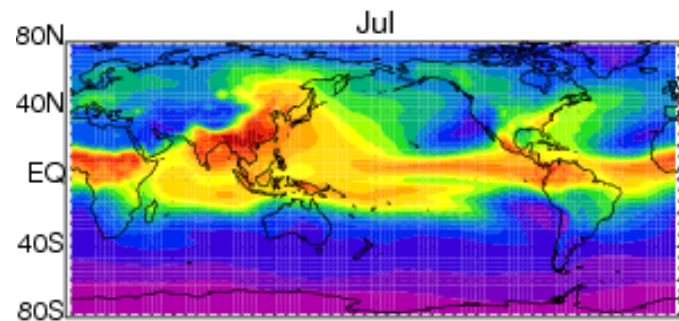
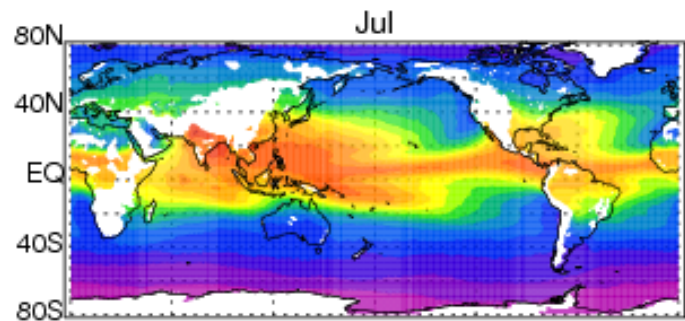
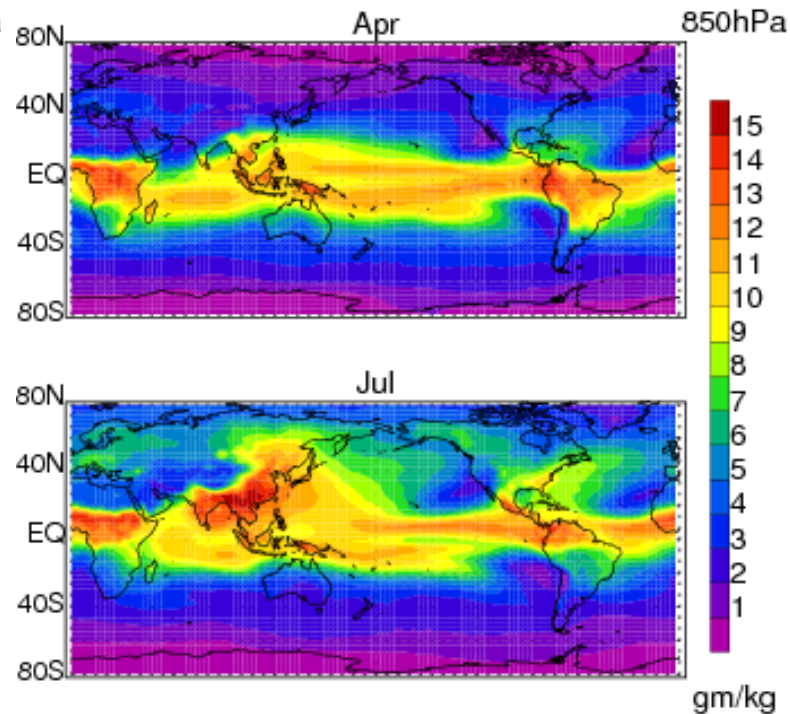
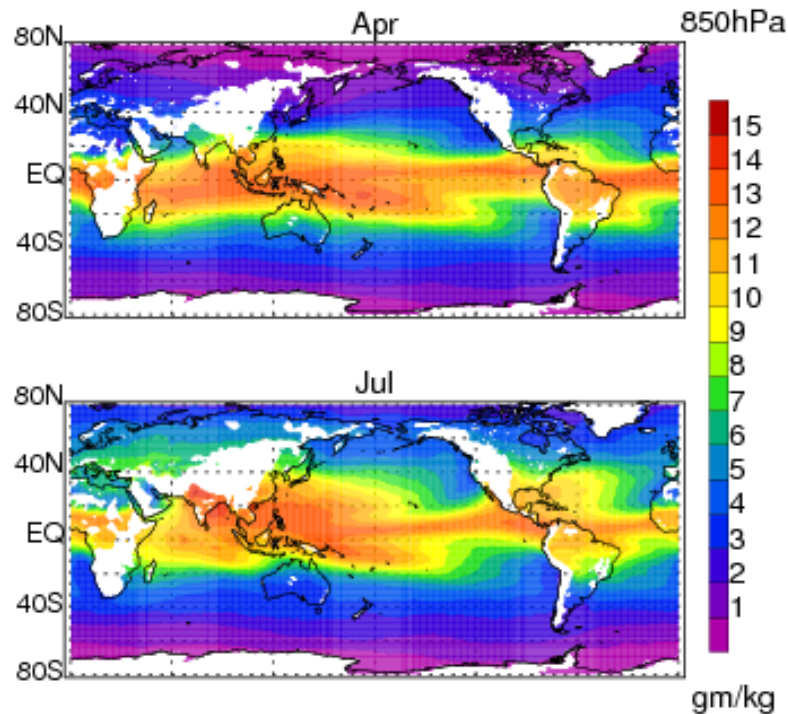
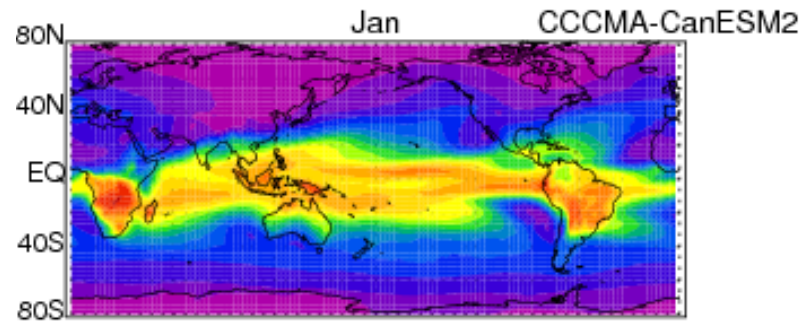
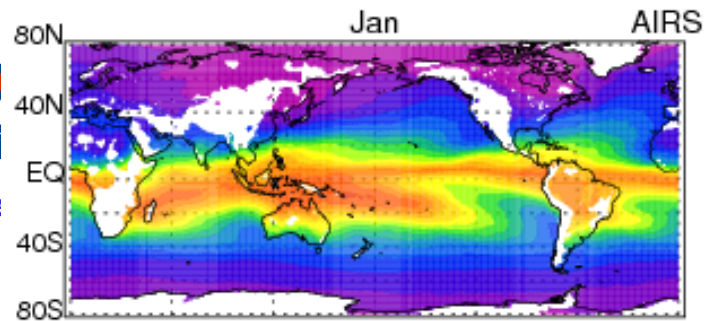
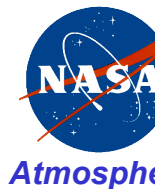


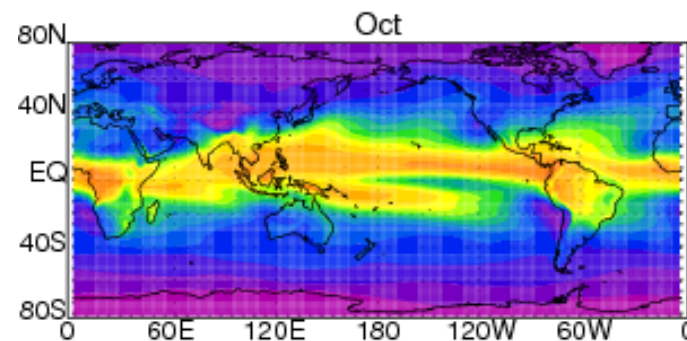
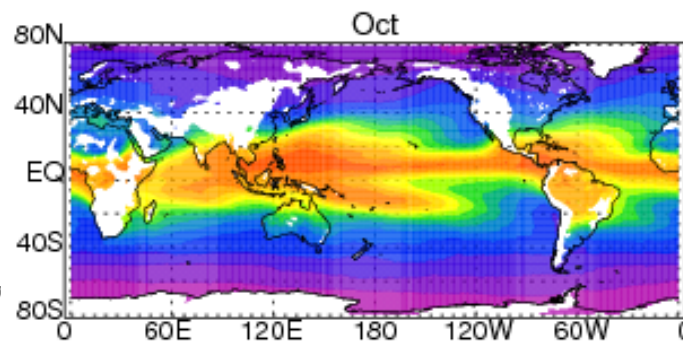
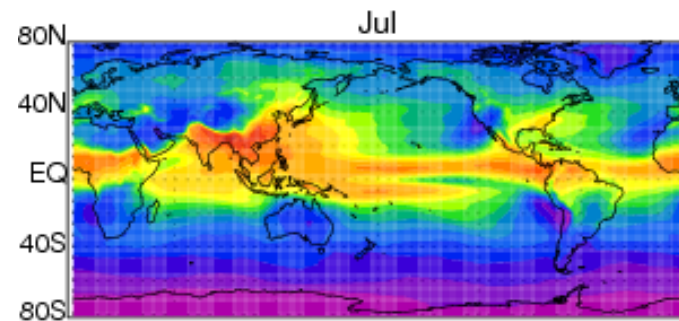
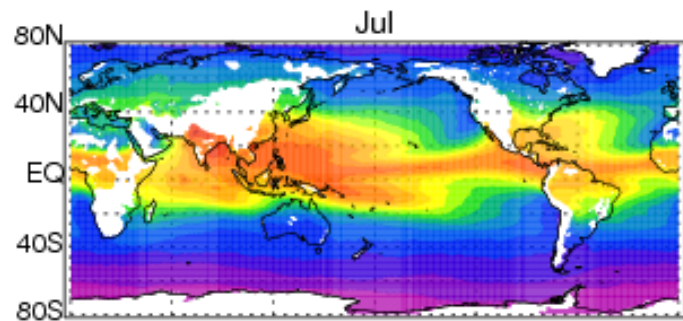
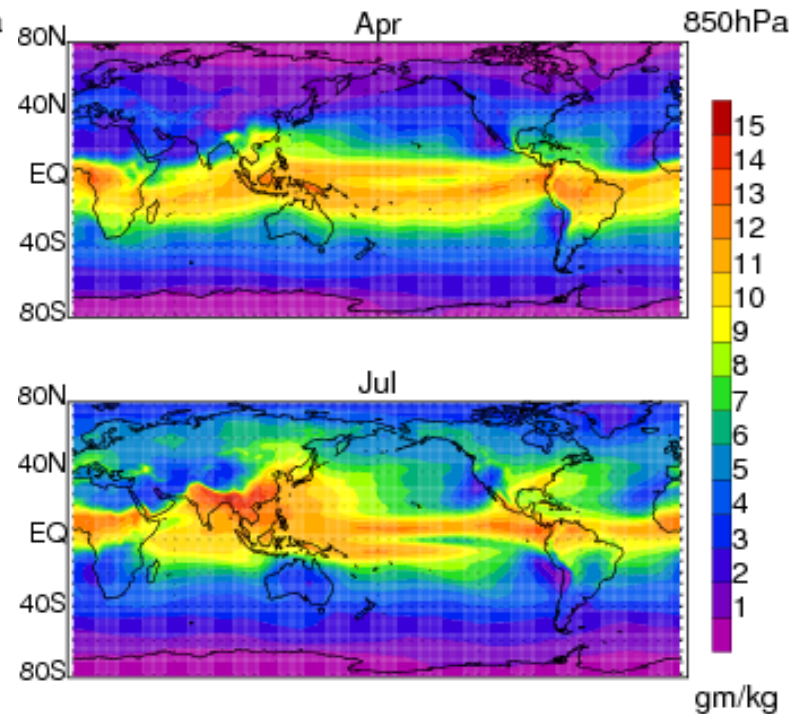
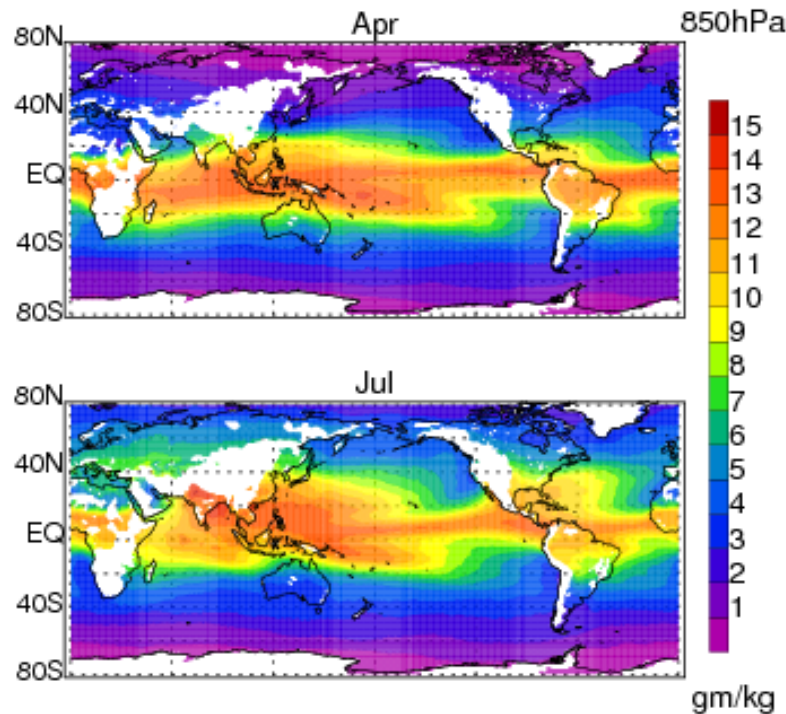
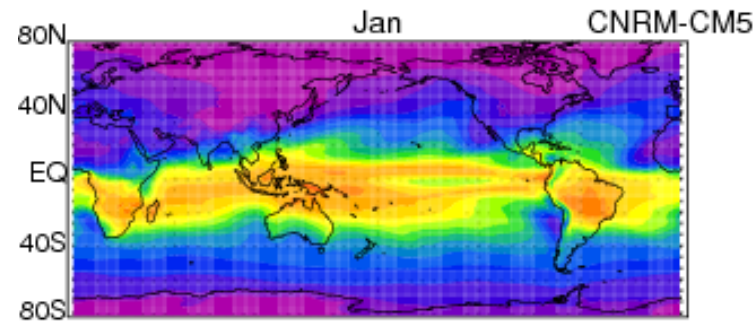
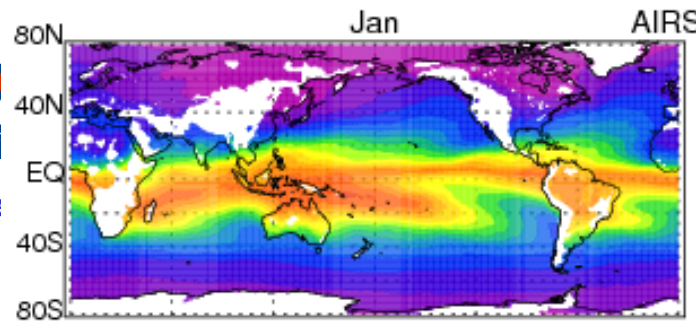
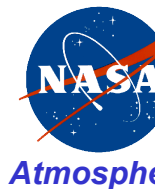


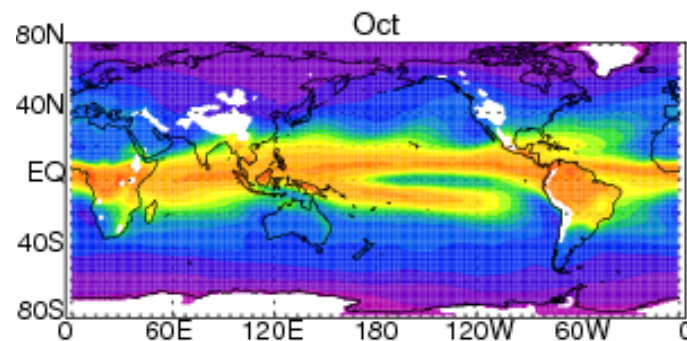
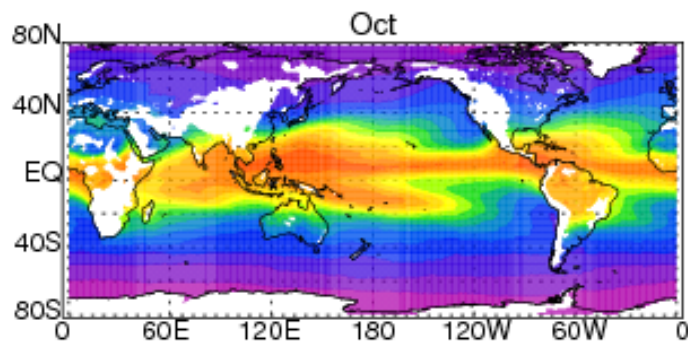
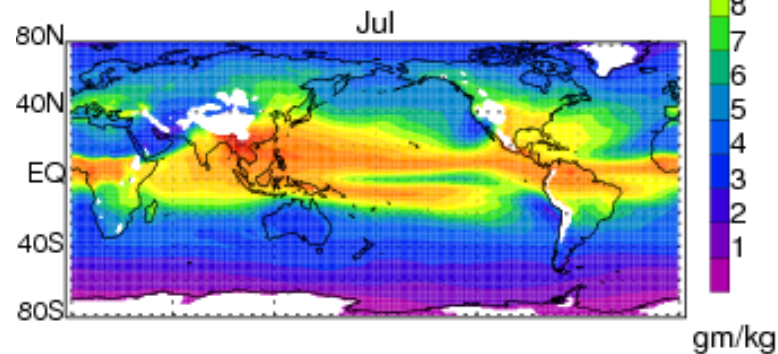
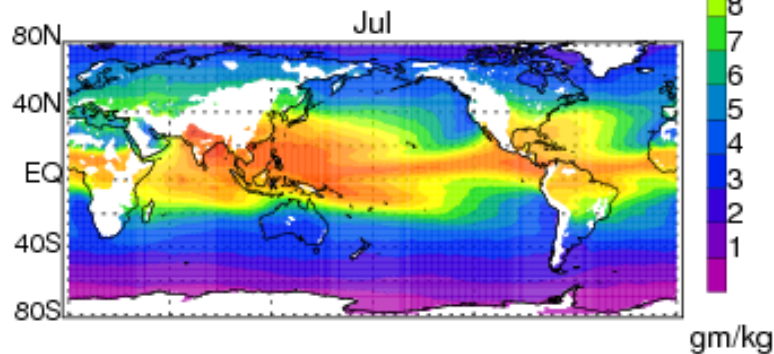
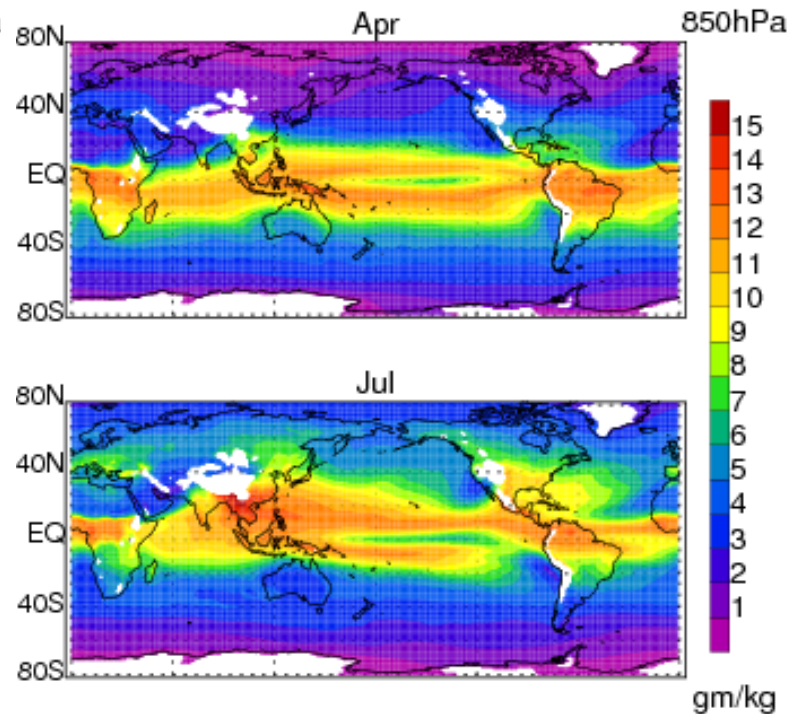
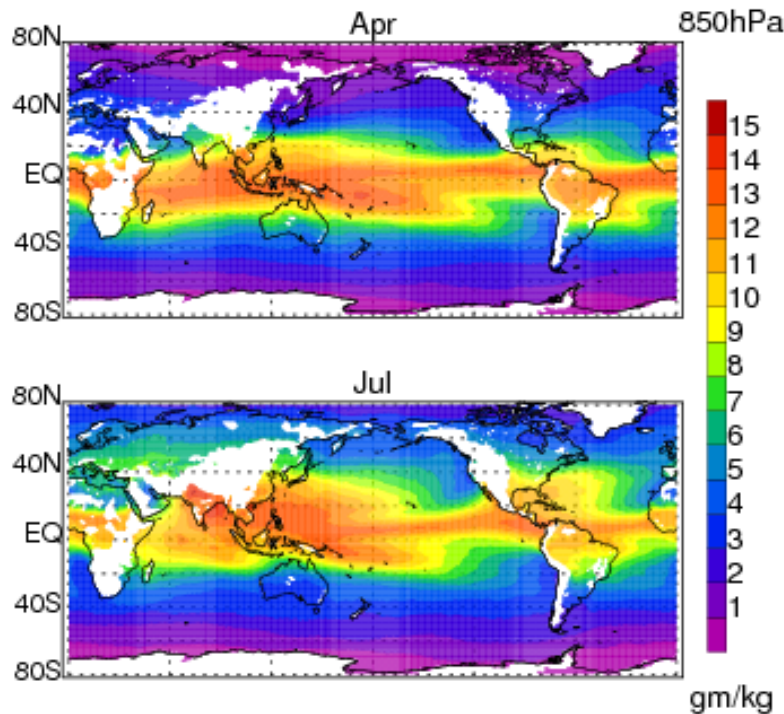
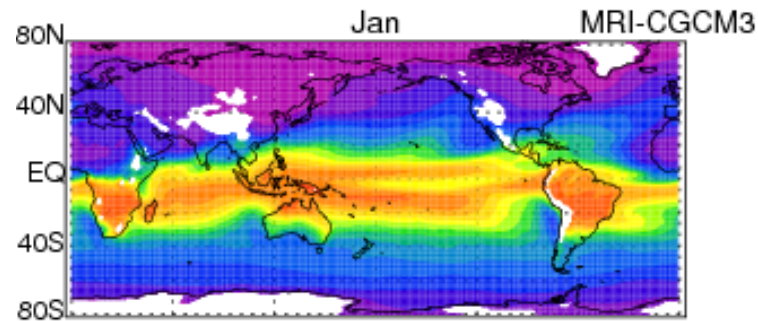
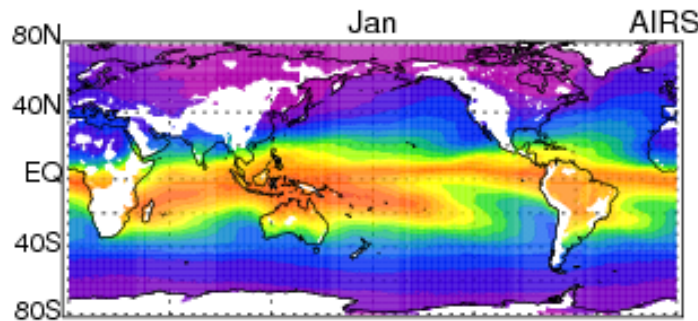
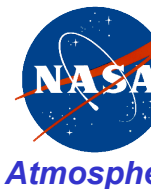
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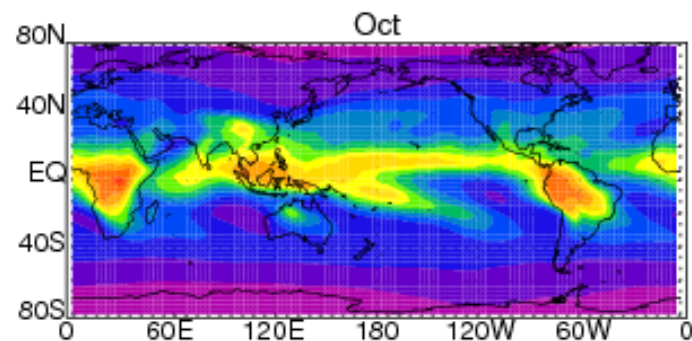
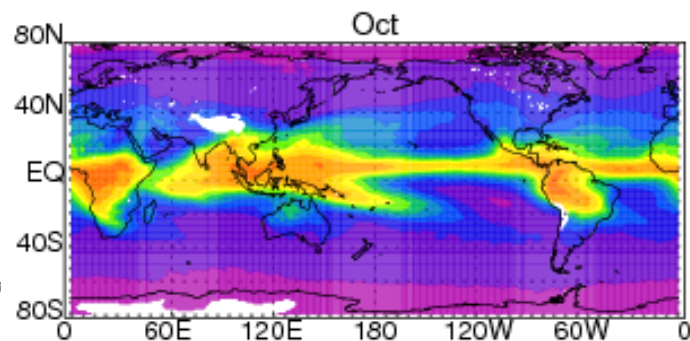
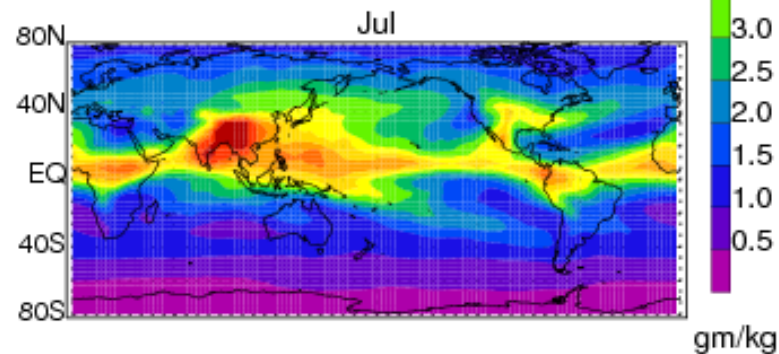
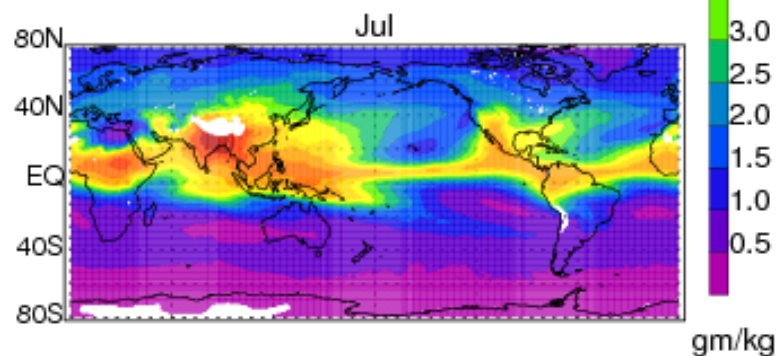
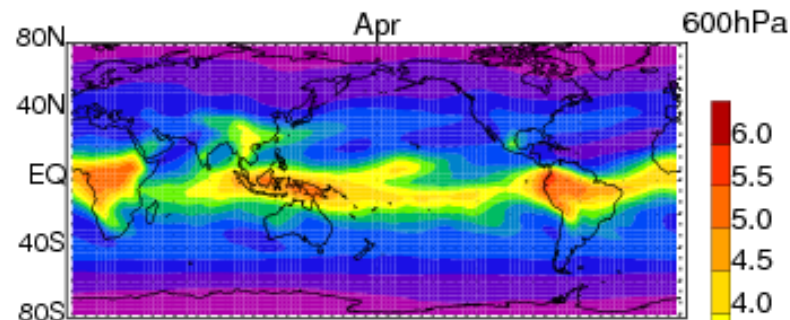
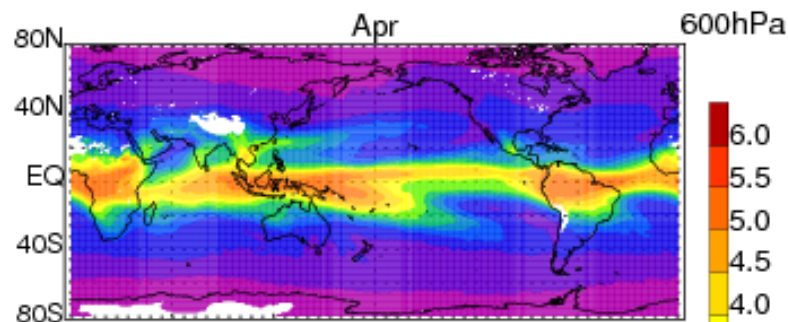
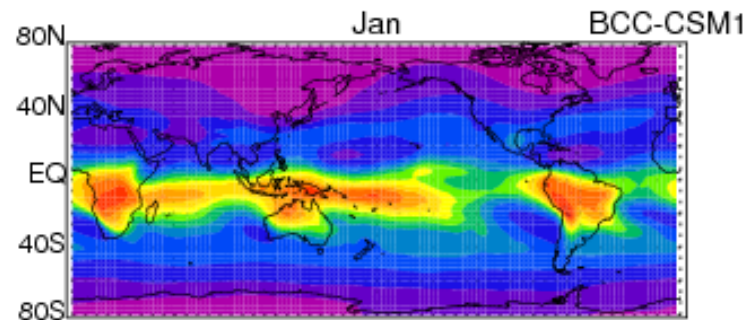
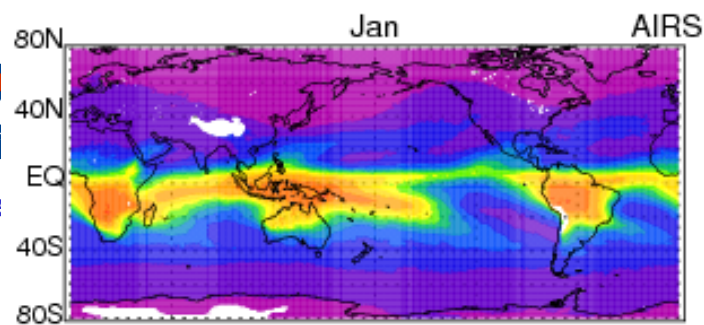
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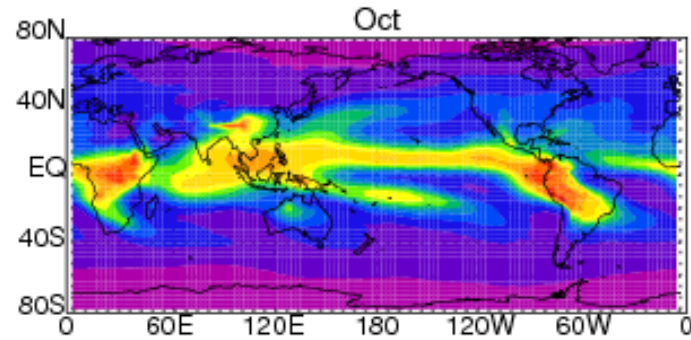
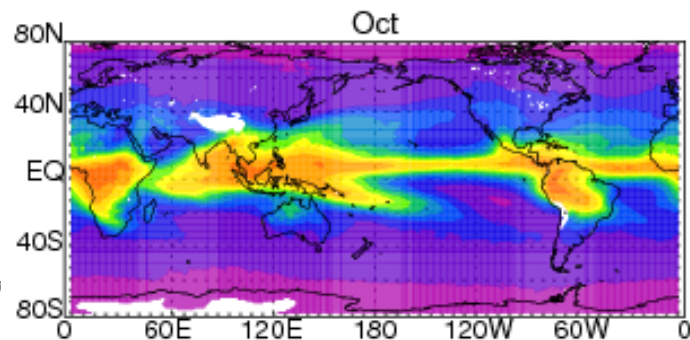
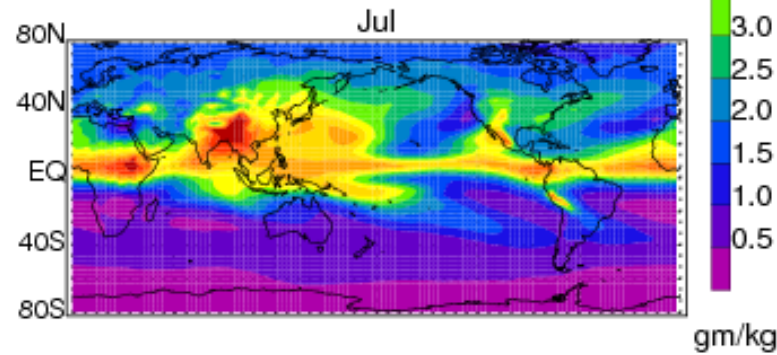
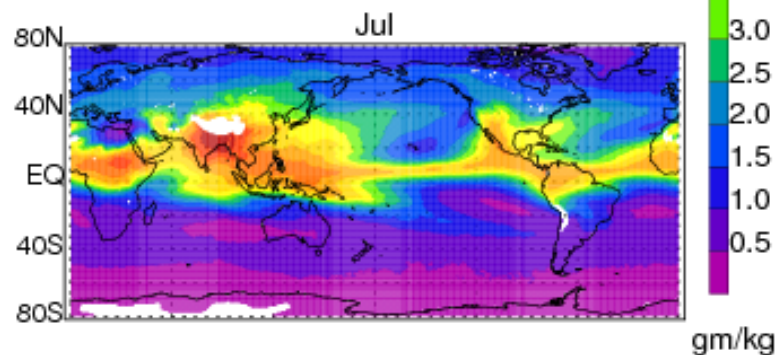
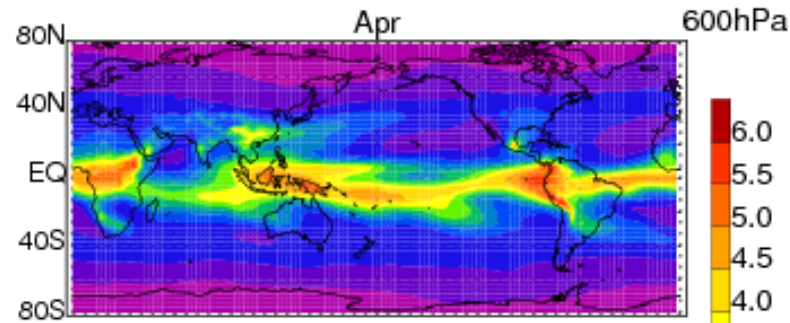
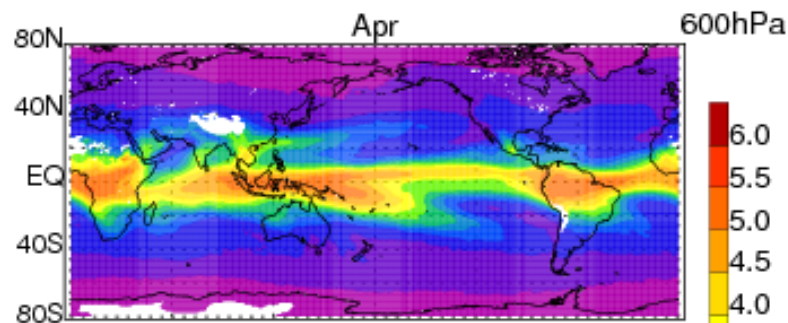
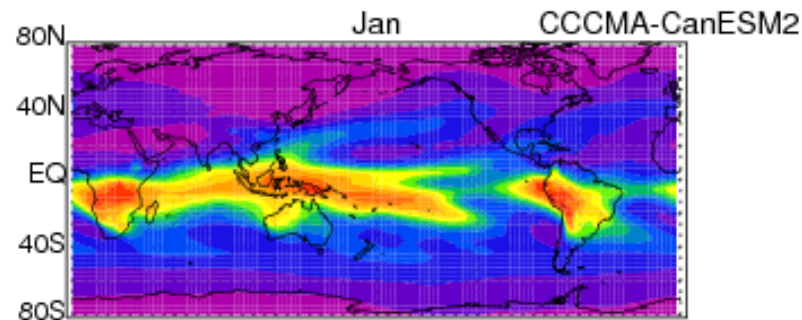
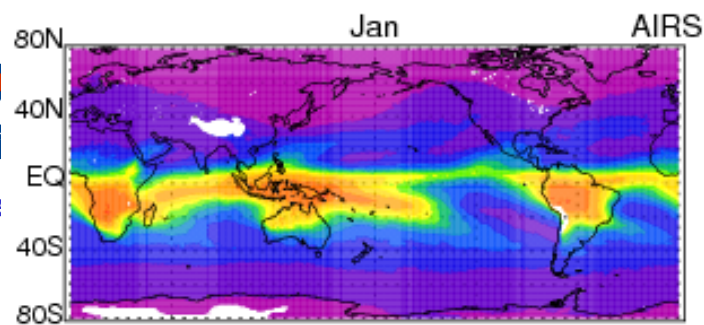


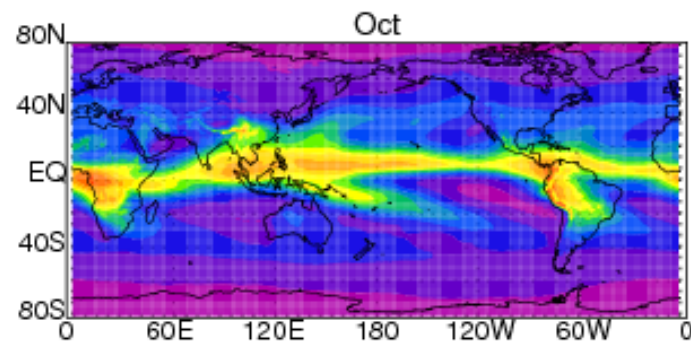
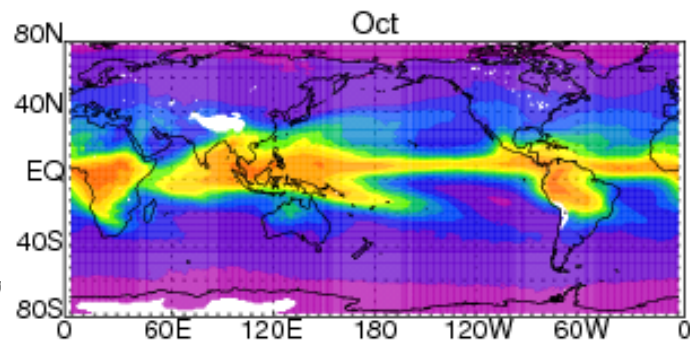
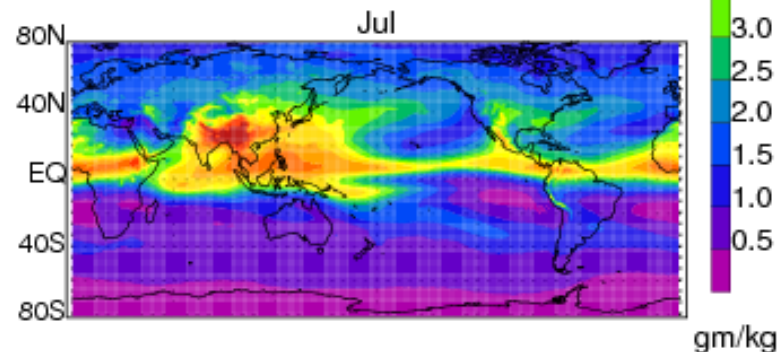
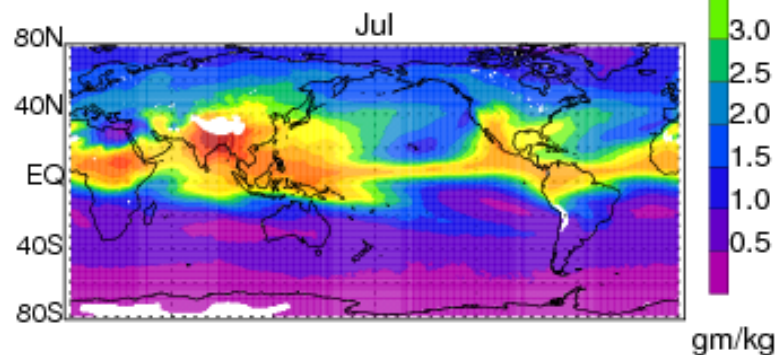
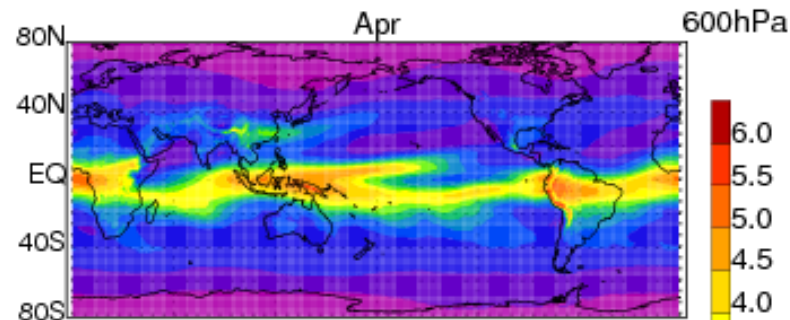
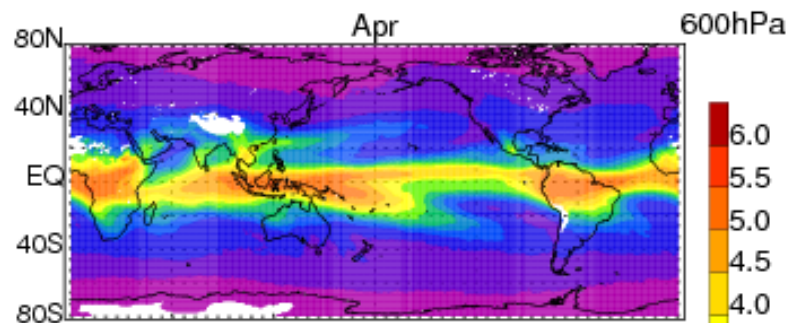
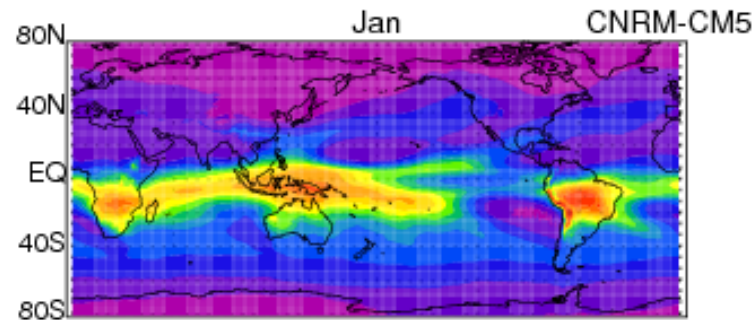
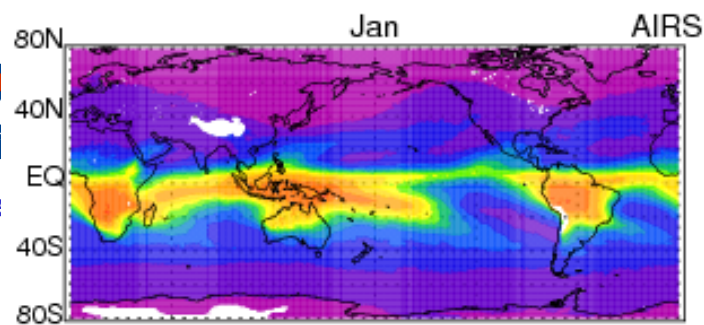


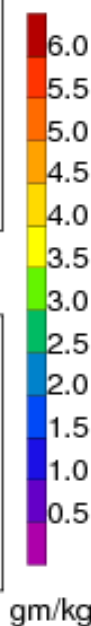
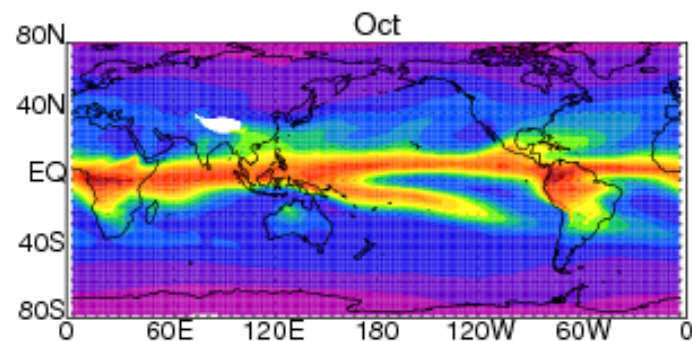
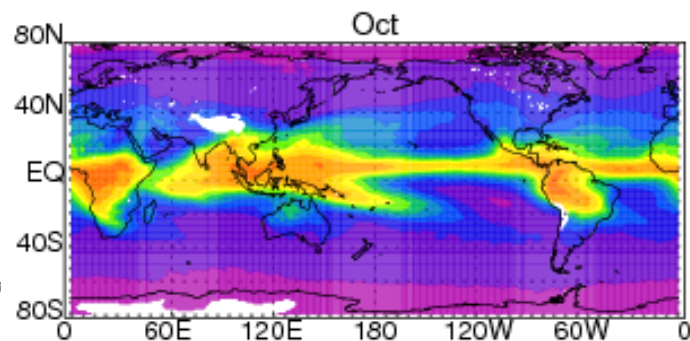
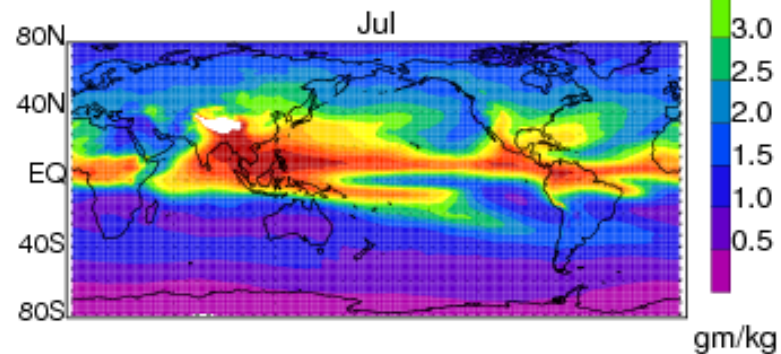
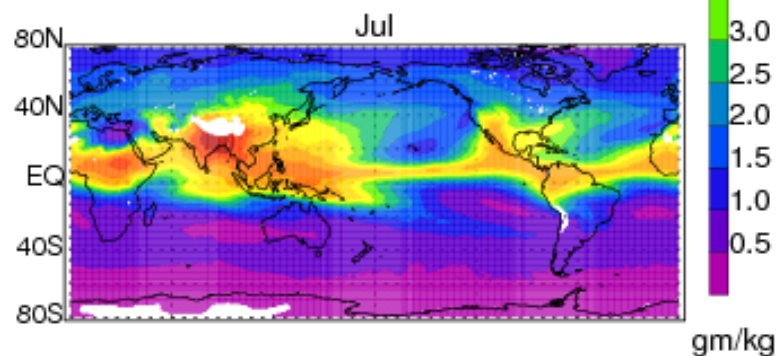
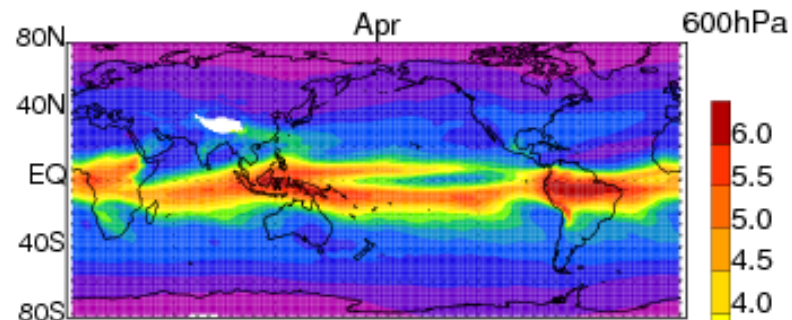
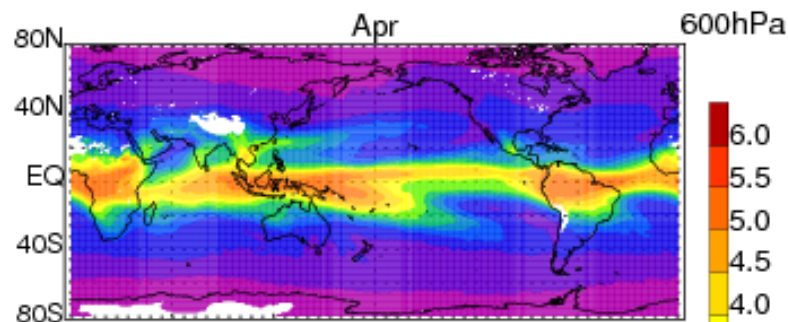
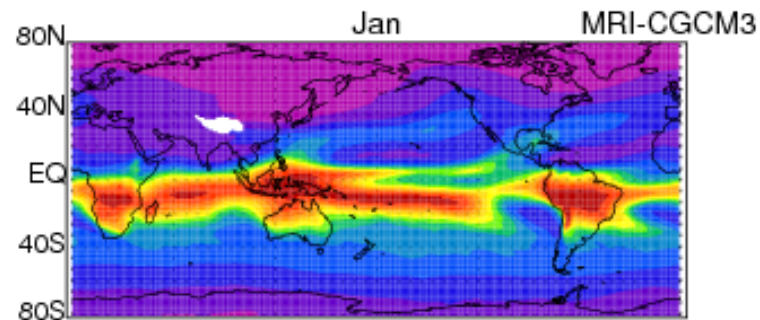
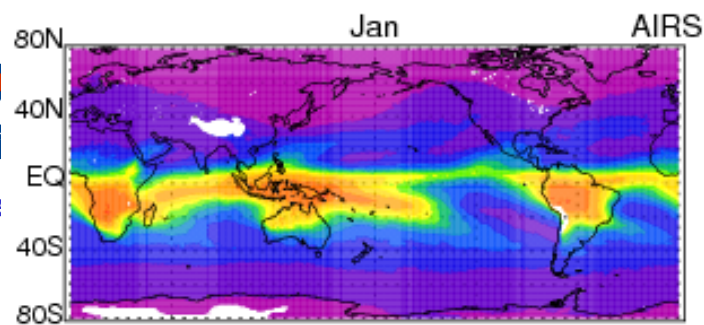


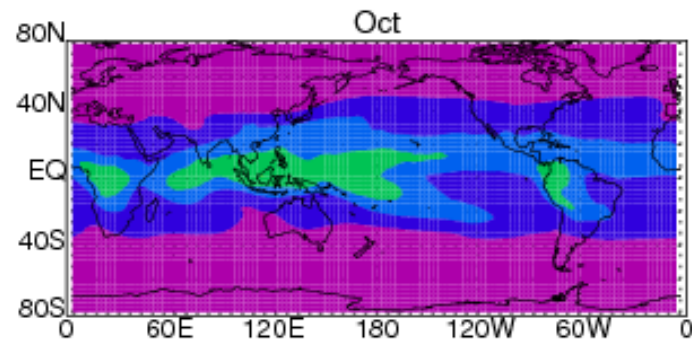
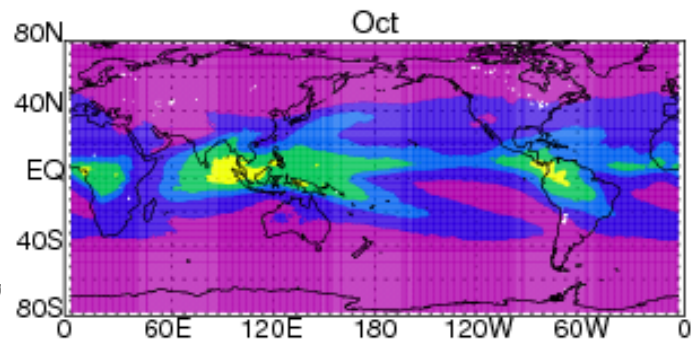
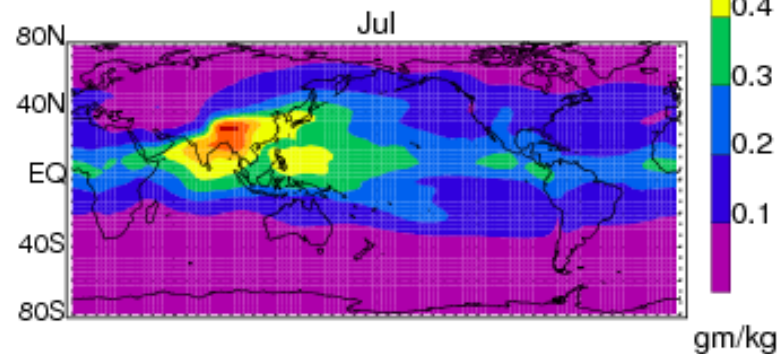
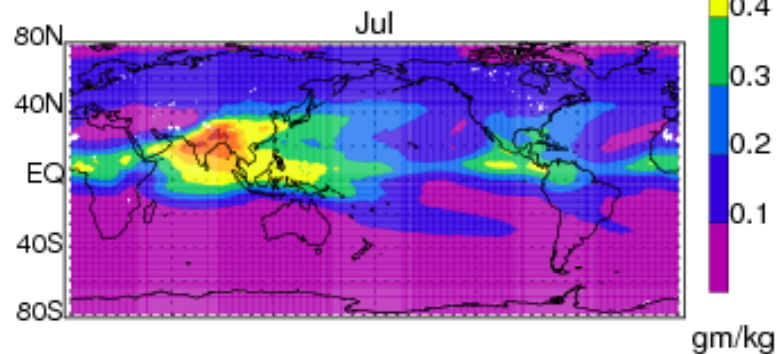
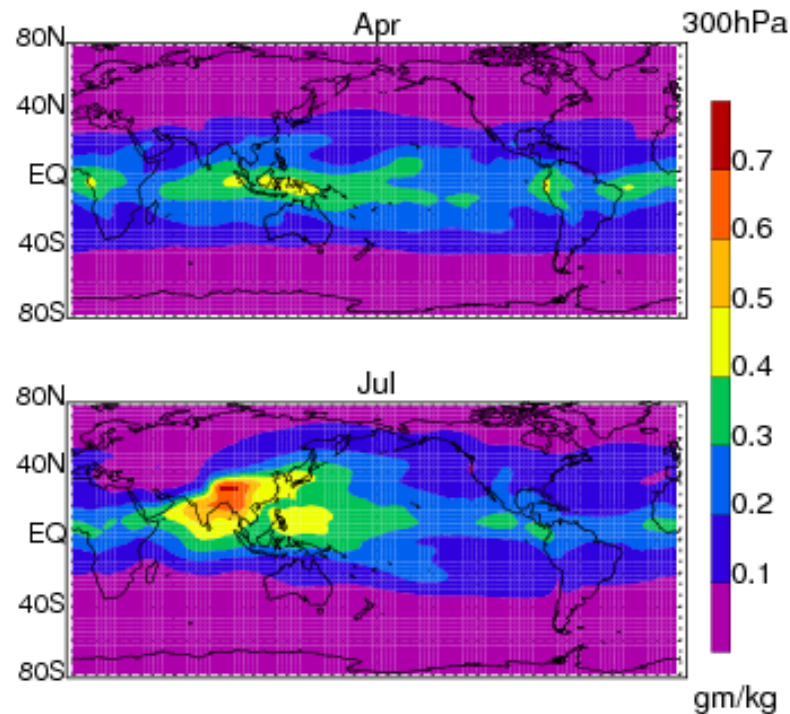
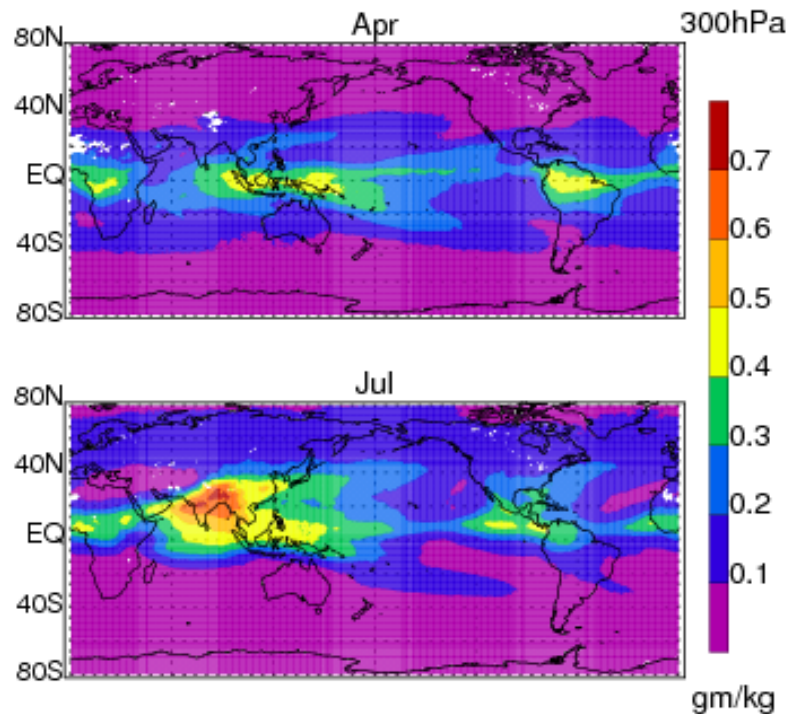
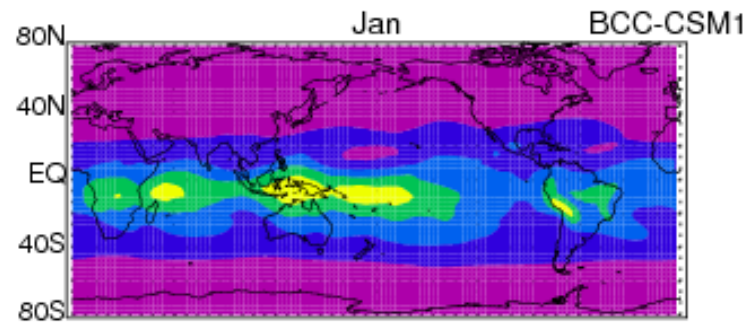
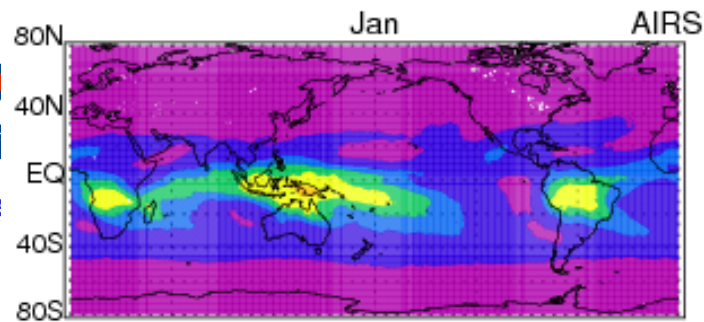
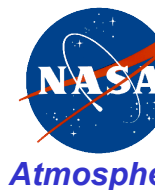


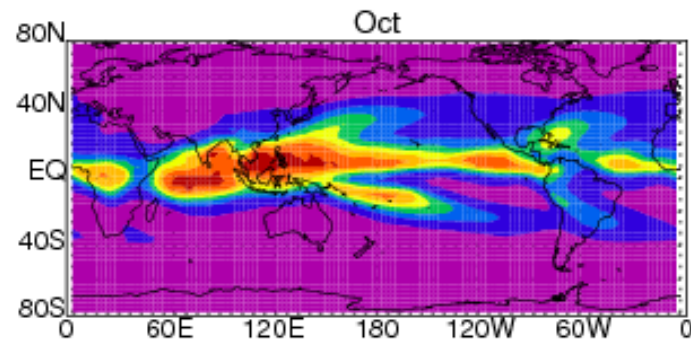
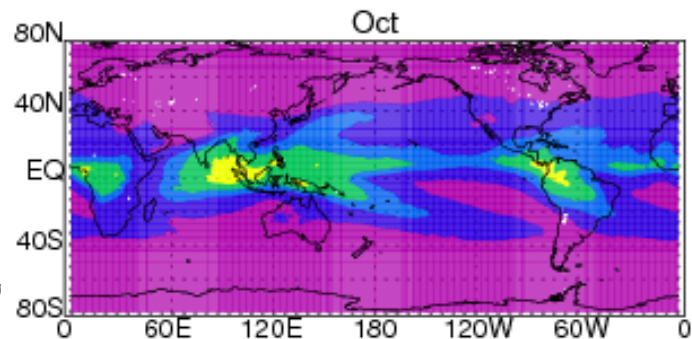
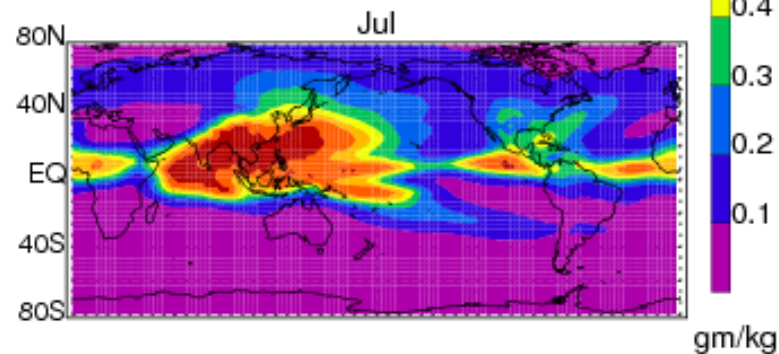
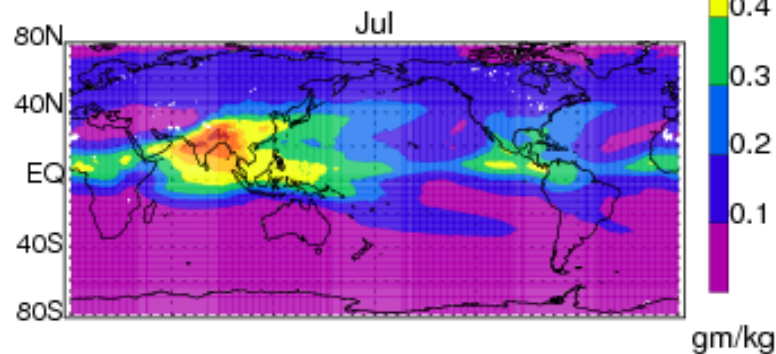
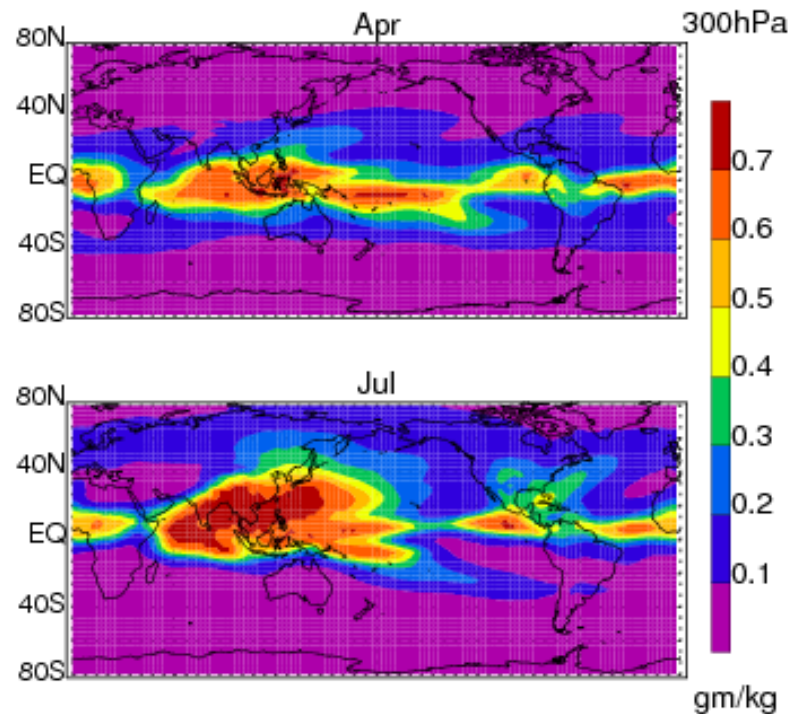
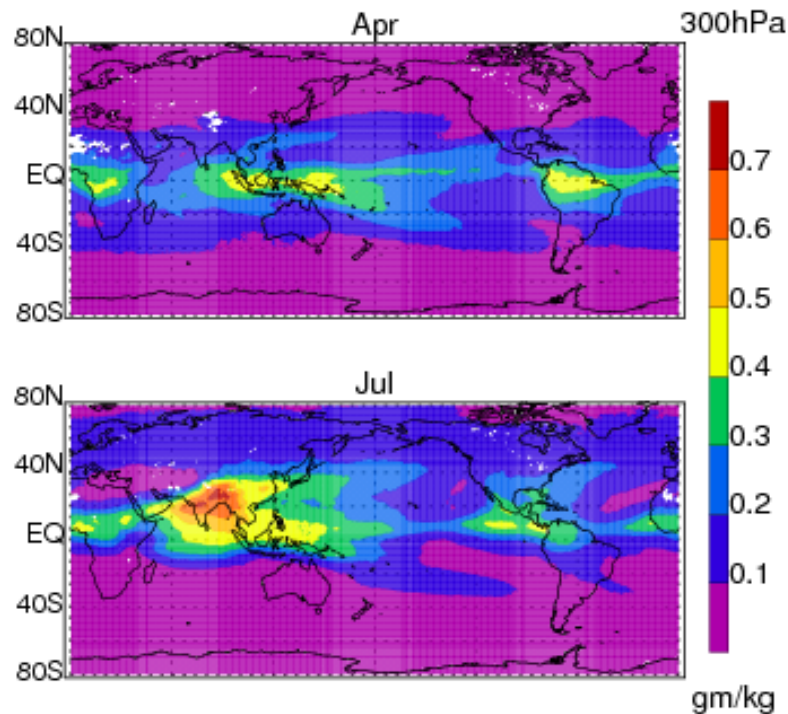
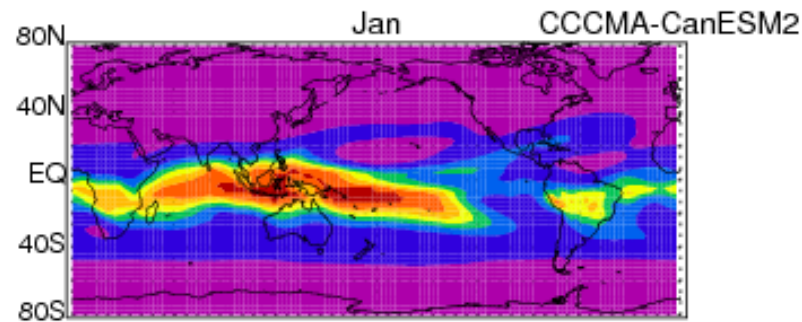
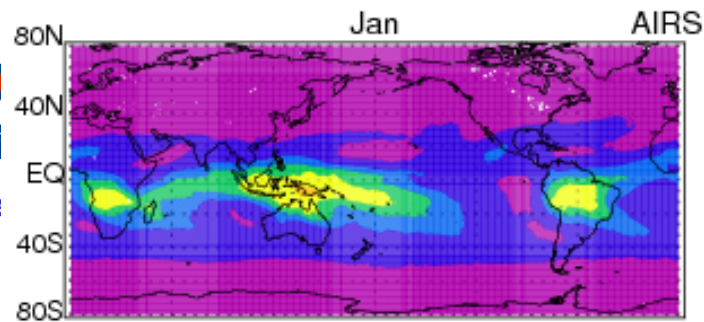
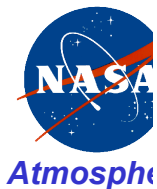


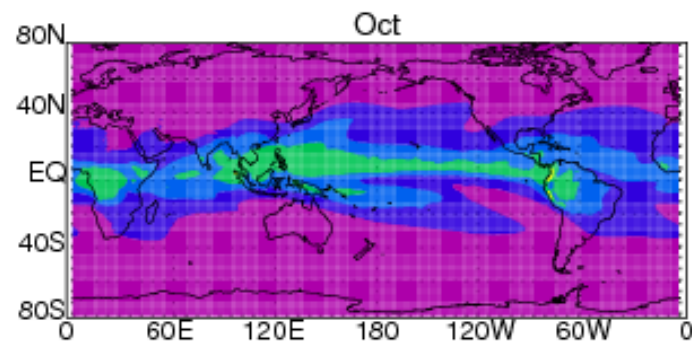
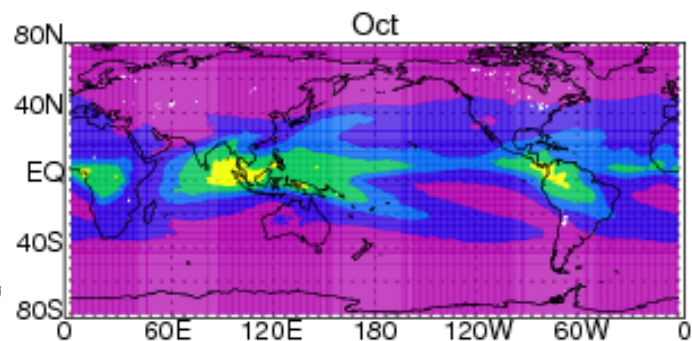
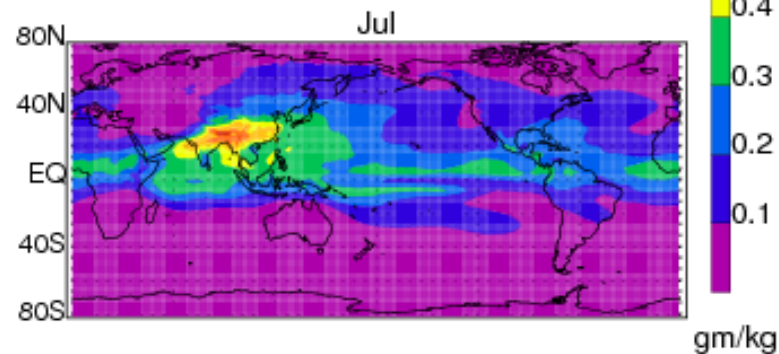
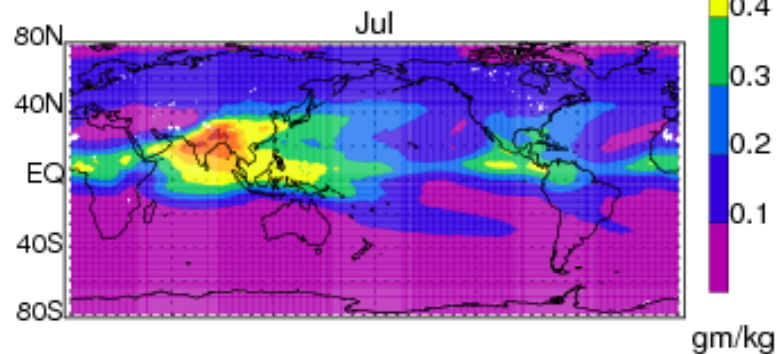
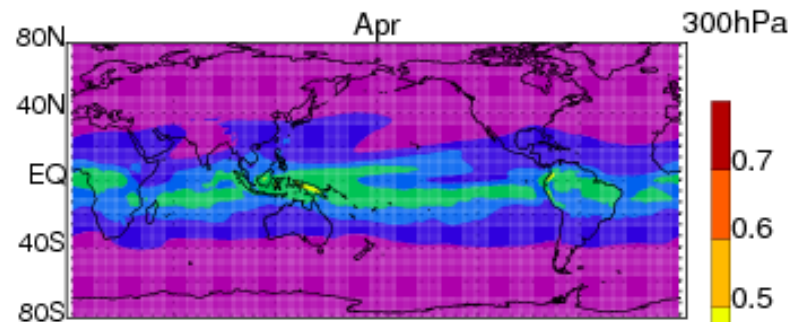
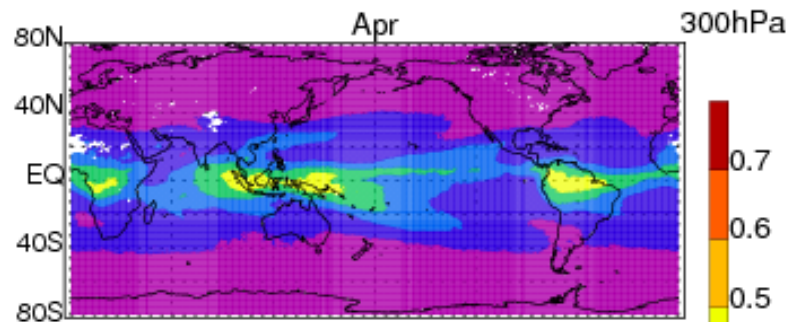
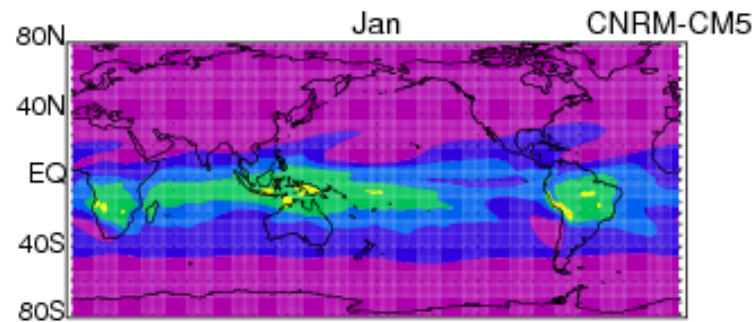
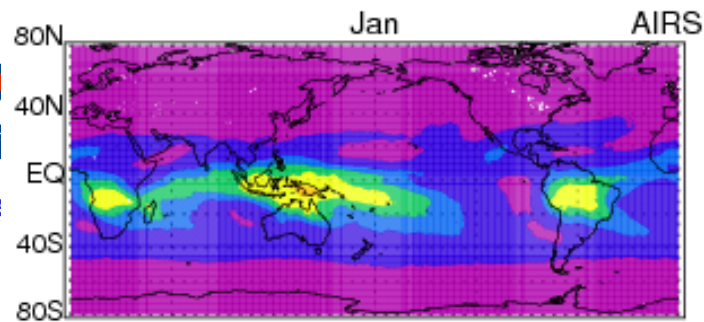


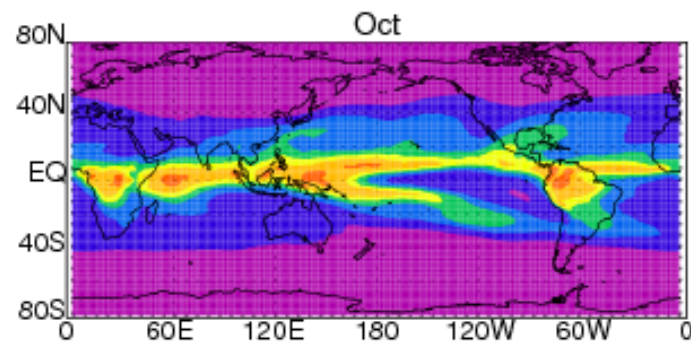
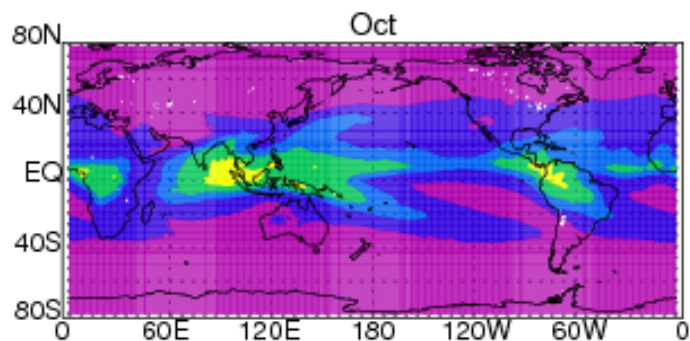
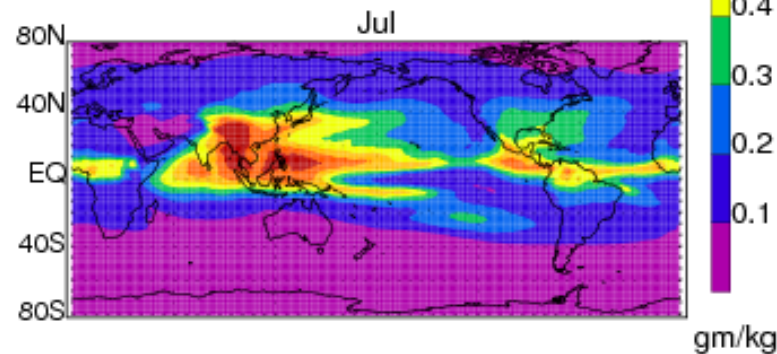
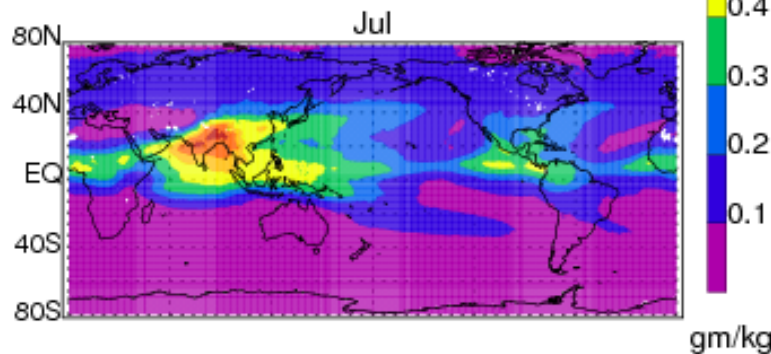
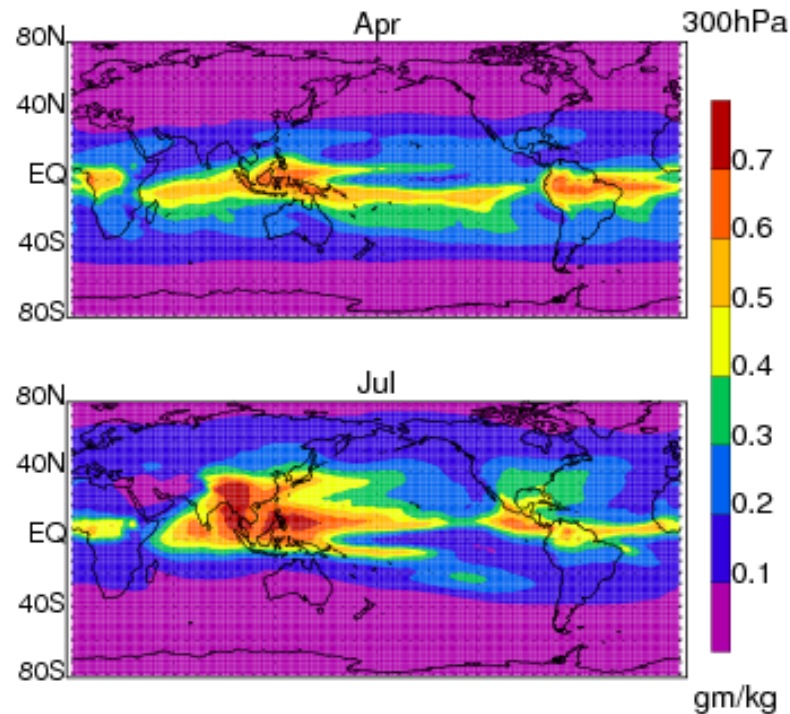
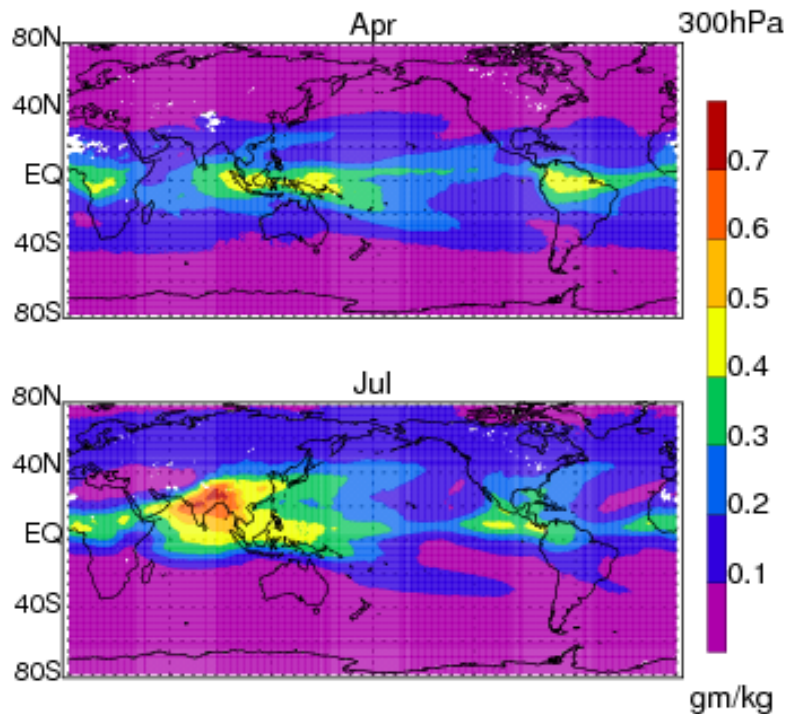
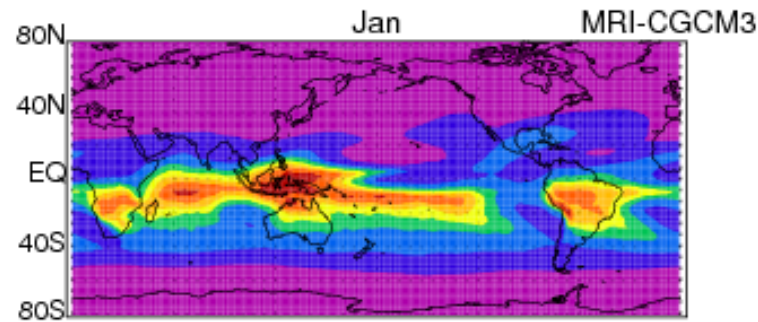
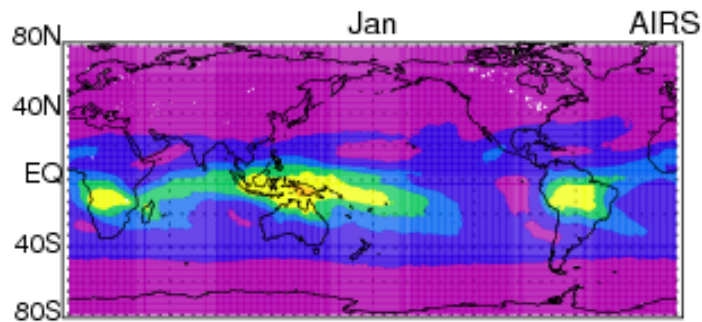
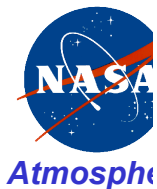


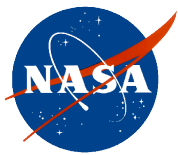






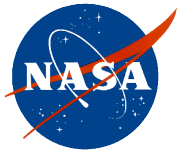






Summary

- The AIRS/CMIP5 data, i.e., monthly averaged air temperature and specific humidity profiles, suitable for CMIP5 model evaluations, were produced and delivered to ESG.
- The basic characteristics of the AIRS/CMIP5 data in terms of climatological mean and seasonal cycle were documented.
- The AIRS/CMIP5 data were used to evaluate CMIP5 models.
- The current available 4 CMIP5 models can simulate the general features of the climatological mean and seasonal cycle of AIRS temperature and water vapor profiles. However, significant biases still exist in these 4 CMIP5 models:
 - Double ITCZs especially in winter and spring seasons for all 4 models
 - Cold bias in the upper troposphere for BCC-CSM1 and CNRM-CM5
 - Moist bias in the upper troposphere for CCCma-CanESM2 and MRI-CGCM3



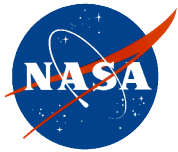
National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Atmospheric Infrared Sounder

Future Work

- These are just preliminary results and more analyses need to be done:
 - Difference maps
 - Vertical profiles at different regions
 - Quantitative assessment of the model performance following Gleckler et al (2008).
 - More models when they are available



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Backup Slides



CMIP5 Simulations

Table 3. Baseline simulations for model evaluation and for understanding historical and paleoclimates. Taylor et al. (2009).

| # | Experiment | Notes | # of years |
|-----|-----------------------------------|---|----------------------------|
| 3.1 | Pre-industrial Control | Impose non-evolving, pre-industrial conditions, which may include: <ul style="list-style-type: none">• Prescribed atmospheric concentrations of all well-mixed gases (including CO₂) and some short-lived (reactive) species• Prescribed non-evolving emissions or concentrations of natural aerosols or their precursors and some short-lived (reactive) species.• Unperturbed land use | 500 (after spin-up period) |
| 3.2 | Historical (1850 – at least 2005) | Impose changing conditions (consistent with observations), which may include: <ul style="list-style-type: none">• atmospheric composition (including CO₂), due to both anthropogenic and volcanic influences• solar forcing• emissions or concentrations of short-lived species and natural and anthropogenic aerosols or their precursors.• land use | ≥156 |
| 3.3 | AMIP (1979 – at least 2008) | Impose SSTs & sea ice (from observations), but with other conditions (including CO ₂ concentrations and aerosols) as in expt. 3.2. See expt. 6.5 for further recommendations from CFMIP. | ≥30 |

